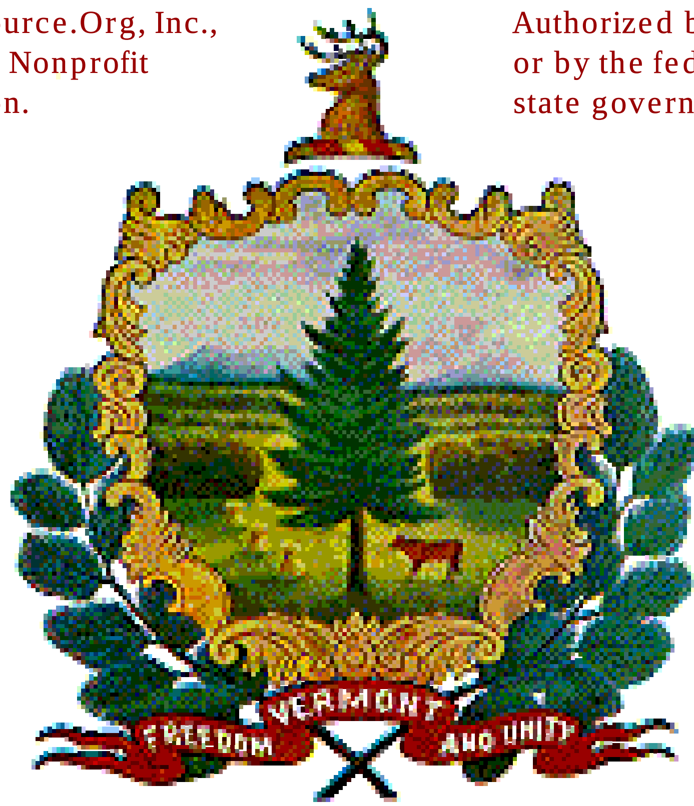
Vermont
Fire & Building Safety Code
2005



VERMONT DEPARTMENT OF PUBLIC SAFETY

DIVISION OF FIRE SAFETY

OFFICE OF THE FIRE MARSHAL AND FIRE ACADEMY

vtfiresafety.org

Effective Date October 22, 2005

2005 Vermont Fire & Building Safety Code
Introduction

Since 1972 the State of Vermont has adopted nationally recognized safety standards to protect the public from fire and explosion hazards and establish standards for fire safety. Standards for boiler safety have been in place even longer. Vermont is able to benefit from the research and fire safety experience from experts across the nation in every area of expertise by using nationally recognized safety standards in this *Code*. The national standards are amended only when necessary to address conditions specific to Vermont, stay within the limits set by law or to clarify interpretations of certain sections.

The *2005 Vermont Fire & Building Safety Code* establishes the process to obtain a construction or operating permit, lists the codes and standards that are adopted and describes the process used to evaluate and grant a variance or exemption from the *Code.* The annexes to this *Code* are designed to help people understand the state laws related to fire, explosion, hazardous materials, structural safety and carbon monoxide, and enable people to understand and take advantage of the flexibility built into this *Code* for historic buildings.

This *Code* establishes separate minimum standards for new and existing buildings, and existing buildings that are used for a new purpose. This *Code* recognizes the need to protect the public when the use of a building changes putting more people at risk or introducing new hazards to a building. But, this *Code* is also written to facilitate the adaptive reuse of buildings recognizing certain limitations of existing buildings. This *Code* has less restrictive requirements for low risk occupancies and promotes the use of alternative solutions for safety.

The *Life Safety Code (NFPA 101)* is the most widely used standard adopted under this *Code* and applies to all buildings and premises regulated under this *Code.* The *Life Safety Code* regulates construction, fire protection and occupancy features necessary to minimize danger to life from fire and to allow escape from fire and non-fire emergencies.

The *Uniform Fire Code (NFPA 1)* applies to new and existing conditions including general fire safety provisions, fire protection including sprinkler systems, fire department access to buildings and special material and process fire hazards. The *Uniform Fire Code* functions as a guide to determine what other specialty codes and state amendments apply to a building, premise, or condition.

The *International Building Code (IBC)* applies to new construction and structural requirements. It is used to determine the allowable size of new construction, structural design features such as the snow load, and to ensure compliance with the performance requirements of other adopted standards.

The *National Board Inspection Code (NBIC)* is focused on the installation, maintenance and inspection of boilers and pressure vessels. The American Society of Mechanical Engineers (ASME) standards referenced in section 3 (b) regulates the design and manufacture of boilers and pressure vessels. Prior to this adoption of this *Code* there had been a separate set of rules for boilers and pressure vessels. By combining the boiler rules with the fire prevention rules there will be a simplified administrative process and better coordination for inspections regarding heating systems.

Information on how to contact the Division of Fire Safety and obtain copies of the adopted codes are in Annex V at the end of this *Code*.

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Introduction

Section 1.
Title, Intent and Authority

(a) These rules are adopted under 20 V.S.A. Chapter 173, Subchapter 2 "Fire Safety Division", Subchapter 3 "Fire Hazards and Dangerous Substances", Subchapter 5 "Boilers and Pressure Vessels" and Chapter 177 "Explosives and Fireworks", and shall be known and cited as the Vermont Fire & Building Safety Code - 2005. It is the intent of these rules to provide for the public safety as directed by these sections of the law.

(b) This *Code* shall be administered and enforced by the Commissioner of Public Safety and staff members of the Division of Fire Safety that are hereby designated to enforce this *Code* and utilize discretionary authority regarding the details of the application of this *Code.* Hereafter the Commissioner, or designated representative, or in the case of a cooperative municipal inspection agreement, the approved inspector(s), are designated as the **Authority Having Jurisdiction** (AHJ). For the purpose of NFPA 1 section 1.13, Certificates of Fitness, the Commissioner and staff members of the Division of Fire Safety are designated as the AHJ.

(c) The AHJ may establish priorities for enforcing these rules and standards based on the relative risk to people and property.

Section 2.
Adoption of Nationally Recognized Standards

The following nationally recognized safety standards, as amended herein, are adopted for the purpose of making rules regarding the safeguarding of people and property in case of fire, explosion, hazardous materials, dangerous structural conditions and the generation of carbon monoxide.

This *Code* has been designed to minimize any conflict or difference between standards. Where there is a conflict between an adopted code and its referenced code or standard the adopted code shall apply. Where there is a conflict between the Life Safety Code (NFPA 101) and another code or standard the Life Safety Code shall apply. Where there is conflict between the Uniform Fire Code (NFPA 1) and the International Building Code or the National Board Inspection Code the Uniform Fire Code shall apply. Where one code or standard has a requirement and another code or standard does not have a requirement the code or standard with a requirement shall apply. When there is a conflict between a general requirement and a specific requirement the specific requirement shall apply.

(a) National Fire Protection Association**,** standard **NFPA 1**, **Uniform Fire Code**, 2003 edition, including those standards referenced in Chapter 2 that shall be considered part of this *Code.*

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-delete- section 1.8 Duties and Powers of the Incident Commander

-delete & replace- section 1.10 Appeals: Requests for variances, exemptions and reconsideration of the interpretation of this *Code*, shall be made and processed in accordance with Section 5 of this *Code*.

-delete & replace- section 1.13.1 Certificate of Fitness: A certificate of fitness is required for all individuals performing activities related to fire or life safety based on the qualifications as follows:

(1) Use of explosive materials – A current explosive license issued in accordance with Title 20 V.S.A. 3072 by the Vermont State Police is required for the use of explosive materials in Vermont.

(2) Blasting operations – A current explosive license issued in accordance with Title 20 V.S.A. 3072 by the Vermont State Police is required for blasting operations in Vermont.

(3) Fireworks displays – (Reserved)

(4) Inspection, servicing or recharging of portable fire extinguishers -(Reserved)

(5) Design, installation, inspection, servicing or recharging of **fixed fire extinguishing systems** – A current certificate from the National Institute for Certificate in Engineering Technologies (NICET) for fire suppression; or training by the manufacturer of fire suppression systems acceptable to the authority having jurisdiction. Eight hours of related instruction is required for certificate renewal.

(6) Design, installation, inspection, maintenance and testing of **fire alarm** and detection systems and equipment – A current master electrician, journeyman electrician or type S journeyman commercial fire alarm license, issued in accordance with Title 26 V.S.A. chapter 15. Eight hours of related instruction is required for certificate renewal. [*72:4.3.3 is deleted and replace by this section*]

(7) (a) **Delivery of liquid propane (LP) gas** – Successful completion of the LP gas Certified Employee Training Program (CETP) books 1.0, 2.2 and 2.4. [*re-lighting a pilot light after an interruption of service is permitted under this certification*]

(b) **Plant Operations for LP gas** – Successful completion of CETP books 1.0, 3.1, 3.2, 3.3 & 3.4

(c) **Design & Selection of LP gas Vapor Distribution System** – Successful completion of CETP books 1.0 & 4.1.

(d) **Preparing & Installing of LP gas Vapor Distribution Components** – Successful completion of CETP books 1.0 & 4.2

(e) **LP gas Transfer Systems operations** – Successful completion of CETP books 1.0 & 5.0

(f) **Installation, Inspection and Service of LP gas Appliances** – Successful completion of CETP books 1.0, 4.2, 6.0 and 7.0. Eight hours of related instruction is required for certificate renewal including at least two hours regarding the prevention of CO leakage and the procedure for safety inspection of an existing appliance – NFPA 54 (annex H).

(g) The installation, inspection and service of **both natural fuel gas systems and equipment, and LP gas systems and equipment** - Successful completion of the AGA course of study including "The Fundamentals of Combustion, Gas Appliance Venting, Electricity, Gas Controls, and Gas Appliances" and CETP books 1.0 and 4.2. Eight hours of related instruction is required for certificate renewal including at least two hours regarding the prevention of CO leakage and the procedure for safety inspection of an existing appliance – NFPA 54 (annex H).

(h) Installation, inspection and service of **natural fuel gas** systems and equipment - Successful completion of the American Gas Association (AGA) course of study including "The Fundamentals of Combustion, Gas Appliance Venting, Electricity, Gas Controls, and Gas Appliances". Eight hours of related instruction is required for certificate renewal including at least two hours regarding the prevention of CO leakage and the procedure for safety inspection of an existing appliance – NFPA 54 (annex H)

(i) Installation, inspection and service of **oil burning equipment –** A Silver certificate from the National Oilheat Research Alliance (NORA). Eight hours of related instruction is required for certificate renewal including at least two hours regarding the prevention of CO leakage and the procedure for inspection.

(j) LIMITED installation, repair and maintenance of **oil burning equipment** not including placing a new unit in service – A Bronze certificate from NORA. Eight hours of related instruction is required for certificate renewal including at least two hours regarding the prevention of CO leakage and the procedure for inspection.

(8) Cleaning, maintenance and evaluation of **chimneys –** A current certificate from the Chimney Safety Institute of America.

(9) Installation, inspection or servicing of range hood systems - (Reserved)

(10) **Calculations and design,** for **fire sprinkler** and standpipe systems, including private underground and aboveground fire mains and fire pumps - A current level III certificate, or higher, for automatic fire sprinkler systems from NICET or a fire protection engineer license issued in accordance with Title 26 V.S.A. chapter 20. A person with a certificate of fitness under this section shall also be permitted to install, maintain, repair and test fire sprinkler and standpipe systems under section 1.13.1 (11).

(11) **Installation, maintenance, repair and testing for fire sprinkler** and standpipe systems, including private underground and aboveground fire mains and fire pumps – Completion of an approved fire sprinkler apprentice program or meeting the testing requirements established by the AHJ. Fifteen hours of related instruction is required for certificate renewal.

(12) LIMITED installation, maintenance, inspection and testing for **domestic fire sprinkler systems** with not more than 6 sprinklers for any isolated hazard area in accordance with 101:9.7.1.2 or an automatic fire sprinkler system in accordance with NFPA 13D, Standard for the Installation of Sprinkler Systems in One and Two Family Dwellings and Manufactured Homes, including multipurpose piping systems – Documented competency and experience acceptable to the AHJ. Eight hours of related instruction is required for certificate renewal.

(13) Installation, maintenance, repair and testing for **emergency generators** – Documented competency and experience through training by the manufacturer or acceptable by the AHJ. Eight hours of related instruction is required for certificate renewal.

[*Information on the periodic inspection & tests of fire protection systems is found in NFPA 1 amended section 4.5.8.4*]

-*add*- section 1.13.4.1 Experience & Training: The AHJ may accept successful completion of appropriate examination or certification other then those listed in this section when the examination or certification demonstrates an equivalent level of experience and training.

-*add*- section 1.13.8.1 Documentation for **Renewal**: An application for renewal shall include:

(1) Documentation of having completed the required hours of approved related instruction regarding this *Code* during the previous certificate period, and

(2) A completed and signed tax certification form in accordance with Title 32 V.S.A.3113, and

(3) A completed and signed child support certification form in accordance with Title15 V.S.A. section 795.

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-*add*- section 1.13.12.4 Due Process: A person who has a certificate of fitness revoked or suspended shall be given written notification and the opportunity for a hearing following due process.

-add referenced standards- section 2.2 Referenced Publications: the following standards are added to section 2.2;
NFPA 53, Recommended Practice on Materials, Equipment, and Systems in Oxygen-Enriched Atmospheres, 1999 Edition.
NFPA 73, Residential Safety Code, as adopted by the Vermont Electrician's Licensing Board.
NFPA 92A, Recommended Practice for Smoke Control Systems, 1996 edition.
NFPA 92B, Guide for Smoke Management Systems in Malls, Atria and Large Areas, 2002 edition
NFPA 101A, A guide on Alternative Approaches to Life Safety 2001 edition.
NFPA 291, Recommended Practice for Fire Flow Testing and Marking of Hydrants, 2002 Edition.
NFPA 601, Standard for Security Services in Fire Loss, Loss Prevention, 2000 edition.
NFPA 720, Standard for the Installation of Carbon Monoxide Warning (CO) Equipment in Dwelling Units, 2005 edition.
NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities, 1999 edition.
NFPA 914, Code for Fire Protection of Historic Structures, 2001 edition

-delete & replace in part - section 2.2 Reference Publications:
Any reference to NFPA 5000, Building Construction and Safety Code, 2003 Edition, shall be to the International Building Code, 2003 edition, as amended in this *code*

-cross-reference – section 3.3.138.11 Health Care Occupancy to section 101:3.3.152.7 as amended

-cross-reference – section 3.3.138.22 Residential Board & Care Occupancy to 101.3.3.152.13 as amended

-add- section 4.5.2.1 **Historic Buildings**: NFPA 914, Code for Fire Protection of Historic Structures, 2001 edition, provides guidance to the AHJ in exercising the discretionary authority granted in section 4.5.2.

-add- section 4.5.7.3 Place of Assembly: A **place of assembly that changes ownership,** or increases the occupant load, shall not be occupied or used until a permit for use and occupancy has been issued by the authority having jurisdiction

-delete & replace- section 4.5.8.4 **Periodic Inspection and Test** of Fire Protection Systems: Inspections and tests of fire sprinkler (other than multipurpose piping systems), suppression, emergency electrical generation, alarm, detection and any other fire protection systems, devices and equipment shall be conducted for the owner by a technically qualified person who has obtained the required certificate of fitness according to section 1.13. Inspections and tests shall be conducted at least annually and cover all intervals of testing frequency for the system. Annual testing by a technically qualified person does not relieve the owner of the responsibility of maintenance, inspection and testing at more frequent intervals as required by this code. A technically qualified person shall file a written inspection report with the AHJ within 14 days of completion of each inspection.

-add- section 4.5.8.5 **Identification of fire protection systems**: A fire protection system identification number, provided by the AHJ, shall be affixed to the control panel, control valve or riser of the fire protection system to provide a unique identification number for the fire protection system.

-add- section 4.5.8.6 **Proof of Inspection**: Proof of inspection, approved by the AHJ shall be affixed by a technically qualified person to the control panel, control valve or riser of the fire protection system after the required inspection has been completed as evidence of that inspection. The proof of inspection fee for fire suppression, alarm, detection and any other fire protection systems shall be $10.00.

-add- section 10.13.4 Truss Construction: All buildings containing truss construction assemblies shall be provided with signage permanently affixed at a height 4 feet above the ground located at the left side of the main entrance door on the address side of the building, at the location of the remote fire alarm annunciation panel or at the fire department connection for the fire sprinkler system. The sign shall be triangular in shape measuring 12 inches horizontally and 6 inches vertically and of contrasting color to the background containing the letter "F" for the truss floor assemblies, the letter "R" for truss roof assemblies and "FR" for truss floor and roof assemblies.

-delete & replace- Section 10.11.1 Permits for Open Fires & Burning: A permit is not required for an open fire where a permit has been obtained from the Town Forest Fire Warden in accordance with Title 10 V.S.A. chapter 83; 2645.

-add- section 10.15.1.1 **Combustible Vegetation**: In other than Health Care, Detention and Correctional occupancies, combustible vegetation, including natural cut Christmas trees otherwise prohibited under table 10.15.1 shall be permitted when located in areas protected by an approved automatic fire sprinkler system.

-delete- section 10.18.1 Permits for Parade Floats
-cross-reference – section 11.1.2 Electrical Installations to 101:9.1.2 as amended

[*Information regarding natural fuel gas- section 11.4: The Department of Public Service regulates the*

*transportation of natural and other gas by **pipeline.** For additional information contact the Vermont Department of Public Service at (802) 828-2811*]

-add- section 11.5.1.4.2 Interruption or **Discontinuance of Gas Service**: Whenever service to a customer is discontinued one of the following must be complied with:

(a) The valve that is closed to prevent the flow of gas to the customer must be provided with a locking device or other means designated to prevent the opening of the valve by persons other than those authorized by the operator.
(b) A mechanical device or fitting that will prevent the flow of gas must be installed in the service line or in the meter assembly.
(c) The customer's piping must be physically disconnected from the gas supply and the open pipe ends sealed. [*reference 54:4.2.1 & 4.2.2*]

-add– section 11.5.1.4.3 **Change in LP Gas Delivery Service:** The building owner, tenant, or responsible party shall obtain a safety inspection that meets or exceeds NFPA 54 annex H, for gas utilization equipment in accordance with section 1.13, when new fuel delivery service is provided.
[*reference 54:8.1.2*]

-add- section 11.5.1.4.4 Room Heater Installations: **Unvented room heaters** and unvented fireplaces shall not be used in any building or structure regulated under this code. [*54:9.23.1 is deleted & replaced by this subsection. It is not the intent of this section to prohibit heaters defined under NFPA 54 sections3.3.67, Direct Gas-Fired Makeup Air Heater, 3.3.130, Industrial Air Heaters, Direct Gas-Fired Non-Recirculating, or 3.3.131, Industrial Air Heaters, Direct Gas-Fired Recirculating, used for large well ventilated areas.*]

-add- section 11.5.1.4.5 Water Heater Installations: Water heaters installed in bedrooms or bathrooms shall be of the direct vent type. [*54:9.28.1.1 is deleted & replaced by this subsection*]

-add- section 13.3.1.2.1 Approval of NFPA 13D Sprinkler Systems:
For all sprinkler systems designed in accordance with 13D, the technically qualified person certified under section 1.13 shall perform all required acceptance tests as required for NFPA 13R sprinkler systems, perform a water flow test for the most remote area, complete the Contractor's Material and Test Certificate(s), and forward the certificate(s) to the AHJ prior to asking for approval of the installation. Where the AHJ desires to be present during the conducting of acceptance tests, the installer shall provide the AHJ 15 day notification of the time and date of the testing. [*13D:4.3 is deleted & replaced by this subsection*]

-add- section 13.3.1.2.2 Arrangement of Fire Department Connections: All new & existing fire department connections shall be arranged so that water from the fire department connection shall reach the sprinkler system regardless of any manually closed control valve. [*NFPA 13:8.16.2.4.3 and 8.16.2.4.4 are amended by this section.*]

-add- section 13.3.1.3.1 **Fire Department Connections for Existing Sprinkler Systems**: Where there is no fire department connection for an existing NFPA 13 or 13R sprinkler system, or the threads do not meet NFPA 13 section 6.8, it shall be listed as a deficiency under NFPA 25: 5.1.1 by the technically qualified person conducting the annual inspection and corrected by the owner or occupant in accordance with NFPA 25: 4.1.4.

-add- section 13.3.1.3.2 **Backflow Prevention for Existing Sprinkler Systems**: A backflow prevention device shall not be added to an existing fire sprinkler system that reduces the water supply or water pressure to a point lower than the minimum sprinkler system design. Sprinkler calculations verifying the modified sprinkler design shall be submitted to the AHJ.

-add- section 13.3.2.1.1 **Sprinkler Protection for Elevator Hoistways**: Sprinkler protection for elevator hoistways shall be in accordance with NFPA 13 as amended in this section for 13:8.14.5:

8.14.5.1 Sidewall spray sprinklers shall be installed at the bottom of each elevator hoistway not more than 2' above the floor of the pit.

8.14.5.2 section deleted

8.14.5.3 Automatic sprinklers are not required for machine rooms constructed of noncombustible construction with the required fire protection rating.

8.14.5.4 Upright or pendent spray sprinklers shall be installed at the top of elevator hoistways. Automatic sprinklers at the top of hoistways shall be of ordinary or intermediate temperature rating.

8.14.5.5 In other than high rise buildings the sprinkler required at the top of the elevator hoistway by 8.14.5.4 shall not be required where the hoistway for passenger elevators is noncombustible and the car enclosure materials meet the requirements of ASME A17.1, Safety Code for Elevators and Escalators.

8.14.5.6 For the purpose of this section elevator hoistways serving 3 stories or less, and machine rooms, shall be considered noncombustible where constructed of independent metal framework and material meeting the definition for limited combustible material under 101:3.3.135.2.

-cross-reference- section 13.3.2.14.2 Sprinkler Systems in New Apartment Buildings with Direct Access to 101:30.3.5.2

-add- section 13.6.1.2.1 Portable Fire Extinguishers for One and Two Family Dwellings: Portable fire

extinguishers shall be provided in accordance with section 13.6 in dwelling units regulated under NFPA 101:24

-cross-reference- section 13.7.1.4.9.2.1 Power for Smoke Alarms to 101:9.6.2.10.2 as amended

-cross-reference- section 13.7.1.4.11.2 Means of Emergency Forces Notification by Fire Alarm to 101:9.6.4.2 as amended

-add- section 14.4.1.1 **Snow Removal**: All portions of the means of egress, including outside stairs and fire escapes, shall be kept clear of any accumulation of snow and ice at all times that the building is occupied. For multi-family dwellings with direct exit access to the outside and one and two family dwellings snow and ice shall be removed as soon as practicable.

-cross-reference- section 14.10.2 Impediments to Egress to 101:7.1.10.1.1

-delete- section 16.6.1 Permits for Torch Applied Roofing Systems

-delete- section 16.7.1.2 Permits for the Placement of Tar Kettles

-delete- section 16.8 Asbestos Removal*:* [*The Vermont Department of Health regulates the removal of asbestos containing materials, as well as the training for persons who remove asbestos containing materials. For additional information, contact the Vermont Department of Health, Health Protection Division (1-800-439-8550).*]

-delete- Chapter 17 Wildland Urban Interface

-delete- section 19.1.1 Commercial Rubbish-Handling Operations Permit

-add- section 20.1.4.6.5 **Means of Egress Inspection, Bars & Nightclubs**: The building owner or agent shall inspect all means of egress in assembly occupancies identified as bars, dance halls, discotheques, nightclubs or where festival seating is used, to ensure all means of egress are maintained free of obstructions, and correct any deficiencies found, prior to each opening of the building to the public. A record, available to the AHJ, shall be kept of all inspections, deficiencies found, and actions taken to correct them.

-cross-reference- section 20.2.3.1.2(1) Emergency Egress and Relocation Drills in Schools to 101:14.7.2.2(1)

-add- section 20.4.2.7 Alcohol-based Hand-rub Solutions: Alcohol-based Hand-rub solutions shall be permitted in health care occupancies when used and stored in accordance with the following:
(1) The maximum individual dispenser fluid capacity shall be 0.3 gallons (1.2 liters) for dispensers in rooms, corridors and areas open to corridors.
(2) The location of dispensers in corridors shall be minimized.
(3) Where multiple dispensers are necessary the minimum horizontal spacing between dispensers shall be 4 ft.
(4) Dispensers shall not be installed over or directly adjacent to an ignition source.
(5) Storage of quantities greater than 5 gallons shall be in accordance with NFPA 30, Flammable & Combustible Liquids Code.

-delete & replace- sections 20.9.2.2, 20.10.2 & 20.11.2 Unvented Fuel-fired Heaters: Unvented fuel-fired heaters shall not be used. [*101: 30.5.2.2; 31.5.2.2; 26.5.2.2 and 24.5.1.2 are deleted and replaced by this section*]

-delete- section 22.2 Automobile Wrecking Yard Permit

-delete & replace- section 25.1.2 **Permits for Membrane Structures, Tents and Canopies**: Permits for an air-supported membrane structure, tent or canopy in excess of 1200 sq. ft. shall comply with 1.12.19.

-add- section 29.1.3 Ventilation for Occupied Spaces Adjacent or Accessory to Parking Structures: In addition to ventilation requirements under 88A:5.3 for enclosed parking structures, all connecting spaces or contained spaces such as offices, waiting areas, ticket booths and similar areas shall be maintained at a positive pressure. (*see section 7 for transition effective date)*

-delete- section 41.1.5 Permits for Welding, Cutting & other Hot Work

*-delete & replace- s*ection 42.2.3.3.2 Aboveground Storage Tanks for Fuel Dispensing: All aboveground storage tanks involved with fuel dispensing shall meet all applicable requirements of Chapter 2 and 3 of NFPA 30, Flammable and Combustible Liquids Code. All aboveground tanks storing Class I liquids shall be **fire resistant tanks** in accordance with Section 42.2.3.4.2.
[*30A:4.3.2 is deleted & replaced by this section*]

-delete & replace- section 42.2.3.3.2.4 Location of Aboveground Tanks for Fuel Dispensing: Tanks involved with fuel dispensing storing Class I liquids shall be located in accordance with Table 42.2.3.3.2.4. Tanks containing other liquids regulated under this chapter shall be permitted to be located with minimum separation requirements ½ of the

distances in Table 42.2.3.3.2.4. [*30A:4.3.2.4 is deleted & replaced by this section*]

-*add*- section 42.2.5.2.1.1 Lighting: Adequate lighting shall be provided for all fuel dispensing locations.

-*add*- section 50.1.1.1 Isolated **Cooking Operations**: The requirements for the hood, grease removal devices, duct and fixed fire extinguishing system may be modified by the AHJ for cooking operations in free standing tents, mobile units or other small buildings located greater than 30' from grandstands or other public buildings and occupied by employees only, when the clearance to combustibles, safety controls, portable fire extinguishers, staff training, fuel use, storage and shut-off, and electrical shut off for equipment are in compliance with this *Code.*

-*delete & replace*- section 51.1.2.1 Permits for Industrial Ovens and Furnaces: Permits for new installations, alterations or extensions to existing equipment shall comply with 1.12.19.

-*add*- section 53.4.1.1 Permits for Mechanical Refrigeration: A permit is not required for an existing facility that is in compliance with reporting requirements under the Vermont Community Right to Know Law, Title 20 V.S.A. Chapter 1.

-*add*- section 60.1.6.1.1 Permits for Hazardous Materials: A permit is not required for an existing facility that is in compliance with reporting requirements under the Vermont Community Right to Know Law, Title 20 V.S.A. Chapter 1.

[*Information regarding chapter 65* ***Explosives and Fireworks****- A license is required to possess, purchase, store, use, transport, give, transfer or sell explosives. For license applications or additional information contact the Division of State Police at (802) 244-8781.*

The Division of Fire Safety regulates the safekeeping, storage, use, manufacturing, sale, handling, and other disposition of explosive material under this Code. The Division of Fire Safety also regulates the construction, manufacturing, storage, handling and use of fireworks for supervised public displays and pyrotechnic special effects under this Code.

It is unlawful for any person to offer for sale, sell at retail or wholesale, possess, use or explode any fireworks except as permitted for a supervised public display of fireworks.

A permit for a supervised public display of fireworks may be obtained from the Chief of the Fire Department, or in towns where there is no Fire Department from the board of selectman, where it is determined the display would not be hazardous to property or endanger the public. Application for a permit must be made at least 15 days in advance of the public fireworks display.

Sparklers *less than 14 inches long with no more than 20 grams of pyrotechnic mixture and novelty sparkling items limited to snakes, party poppers, glow worms, smoke devices, string poppers, snappers, or drop pops with no more than 0.25 grains of explosive mixture, that are in compliance with United States Consumer Product Safety Commission regulations, are legal for sale and use in Vermont.*]

-*delete & replace* - section 65.2.3 **Permits for Public Fireworks Displays**: A permit for a supervised public display of fireworks shall be obtained from the chief of the fire department, or in towns where there is no fire department the board of selectmen, after determining the display would not be hazardous to property or endanger the public.

-*delete & replace*- section 65.11.1.1 **Consumer Fireworks**: The sale, handling and storage of consumer fireworks, including sparklers permitted for sale in Vermont, in both new and existing buildings, structures and facilities shall comply with NFPA 1124 and section 65.11.

-*delete & replace*- section 65.11.1.3.1 Exempt Amounts of **Consumer Fireworks**:
Consumer fireworks retail sales facilities or stores where the fireworks and sparklers are in packages in accordance with the U. S. Consumer Product Safety Commission and where the total quantity of consumer fireworks and sparklers in the building does not exceed 125 lb (net) of pyrotechnic composition shall be exempt from the following sections:
-65.11.3[*1124:7.3*] Permits
-65.11.4[*1124:7.4*] Construction
-65.11.5.1[*1124:7.5.1*] Automatic Sprinkler System
-65.11.5.3[*1124:7.5.3*] Fire Alarms
-65.11.5.4[*1124:7.5.4*] Smoke Control
-65.11.7[*1124:7.7*] Separation distances

-*add*- section 66.1.5.1 Permits for Flammable & Combustible Liquids: A permit is not required for an **underground storage tank** regulated by the Agency of Natural Resources, Department of Environmental Conservation, according to NFPA 30. [*The Agency of Natural Resources, Department of Environmental Conservation (DEC) regulates petroleum and chemical Underground Storage Tanks (USTs) that are 10 percent or more beneath the surface of the ground. All USTs are required to be registered with the Agency except for: (a) Tanks less than 1100 gallons containing fuel oil (#2-#6) which is used for on premises heating and domestic hot water, and (b) farm and residential tanks less than 1100 gallons containing motor fuel which is used for noncommercial purposes. In addition, certain*

registered USTs are required to have permits for their operation and are subject to other operational standards. All USTs are subject to closure (removal) requirements upon being taken permanently out of service. For additional information contact the Vermont DEC at (802) 241-3888.]

-*add*- section 69.1.1.4 **Record of Installation for LP Gas Containers**: Installers shall maintain a record of all installations for which a permit is not required by section 69.1.1.3, but not including replacing of portable cylinders, available for inspection by the AHJ.

- *add*- section 69.3.2.6.5 LP Gas, Container Valves: Containers over 4,000 gallon (15.2m^3) water capacity shall be equipped as required in section 58:2.3.3.2(b) (1) & (2). Internal valves with pneumatic shut-offs, or other approved safety designs, shall be required for new installations. [*58:2.3.3.2(b) is amended by this section*]

-*delete & replace*- section 69.3.2.4.2 **LP Gas Systems, Protection from Damage**: Where physical damage to LP Gas containers or systems of which they are a part, from vehicles is a possibility, physical protective barriers shall be provided to protect against such damage. [*58:3.2.4.2 is deleted & replaced by this section*]

-*add*- section 69.3.2.4.2.1 **Underground LP Gas Systems, Protection from Damage:** Where containers are installed underground within 10' of where vehicular traffic can be expected, physical protective barriers shall be provided for the fitting housing, housing cover, tank connections, and piping, to protect against vehicular damage. All other underground containers shall be provided with a reflective marker or other readily visible marker acceptable to the authority having jurisdiction, at 4' in height to mark the location of the housing cover. [*58:3.2.9.1(c) is deleted & replaced by this subsection*]

-*delete & replace*- Section 70.1.2.1 Permits for Oxidizers and Organic Peroxides: A permit is not required for an existing facility that is in compliance with reporting requirements under the Vermont Community Right to Know Law, Title 20 V.S.A. Chapter 1.

(b) National Fire Protection Association standard **NFPA 101**, **Life Safety Code**, 2003 edition, including those standards referenced in Chapter 2, that shall be considered part of this *Code.*

-*delete & replace in part*- section 2.2 National Electrical Code & Residential Electrical Safety Code: Any reference to NFPA 70 and 73 in this *Code* shall be to the edition adopted by the Vermont Electricians Licensing Board.

-*delete & replace in part* - section 2.2 Reference Publications: Any reference to NFPA 5000, Building Construction and Safety Code, 2003 Edition, shall be to the International Building Code, 2003 edition, as amended in this *code*

-*delete & replace in part*- section 2.3.4 Safety Code for Elevators: Any reference to ASME 17.1 or 17.3 in this *Code* shall be to the edition adopted by Vermont Elevator Safety Review Board.

-*delete & replace*- section 3.3.152.7 Definition of **Health Care Occupancy**: An occupancy used for purposes of medical or other treatment or care of three or more persons where such occupants are mostly incapable of self-preservation due to age, physical or mental disability, or because of security measures not under the occupant's control.

-*delete & replace*- section 3.3.152.13 Definition of **Residential Board & Care Occupancy**: A building or portion thereof that is used for lodging or boarding of three or more residents, not related by blood or marriage to the owners or operators, for the purpose of providing personal care services.

-*add*- section 7.1.10.1.1 Clearance for **Inclined Lifts on Stairways**: Where a platform or chair lift is installed on an exit stair in an existing building the minimum clear width on the stair when the inclined lift is in the down position shall be

- 18" when the stair serves fewer than 10 people
- 22" where the stair serves fewer than 50 people
- as required by this *Code* when the stair serves 50 or more people

Where a platform or chair lift is installed on an exit stair in a new building the minimum clear width on the stair when the inclined lift is in the down position shall be as required by this *Code.*

-*delete & replace*- section 7.2.2.6.5 Outside Stairs, Accumulation of Snow, Ice or Water: New outside stairs and landings, other than the primary entrance, shall be designed to minimize the accumulation of snow, ice and water by a roof or other approved means. [*cross reference to 1:14.4.1.1*]

-cross-reference- amendments to NFPA 54, Fuel Gas Code, and NFPA 58, LP Gas Code, 1: 11.5.1.4

-*add*- section 7.12.3 **Boiler Room Exits**: Two means of egress shall be provided for boiler rooms exceeding 500 sq. ft. floor area and containing one or more boilers having a fuel capacity of 1,000,000 BTU/HR or more. Each elevation shall be provided with at least two means of egress, each to be remotely located from the other. A platform at the top

of a single boiler is not considered an elevation. [*reference NBIC I-2341*]

-delete & replace- section 9.1.2 **Electrical Systems**: All electrical wiring and equipment shall installed and maintained in accordance with NFPA 70, National Electrical Code and NFPA 73, Residential Safety Code, as adopted by the Electricians' Licensing Board.

-delete & replace- section 9.6.2.10.2 **Power for Smoke Alarms**: All newly installed smoke alarms in one & two family dwellings, multiple unit dwellings, lodging or rooming houses, hotels and dormitories shall be directly wired to a non-dedicated electrical branch circuit for the building and by battery.

- delete & replace- section 9.6.4.2 Means of Emergency Forces Notification: Where fire department notification is required by another Section of this *Code*, the fire alarm system shall be arranged to transmit the alarm automatically via the most acceptable means available and in accordance with NFPA 72, *National Fire Alarm Code.*

Listed in order by the most acceptable to the least acceptable means of notification:

(1) Fire Department Master or Radio Box.
(2) Leased direct line to the Fire Department.
(3) Leased direct line to the Police Department or dispatching agency for the Fire Department.
(4) Approved Central Station - UUFX providing protective signaling services.
(5) Approved Central Station - CVSU providing monitoring services.
(6) Proprietary system.
(7) Recognized remote station.
(8) Digital dialer connected to approved remote station.
(9) Listed commercial digital dialer.

[*1:13.7.1.4.11.2 is deleted & replaced by this subsection*]

-cross-reference- section 9.7.1 Back Flow Prevention for Existing Sprinkler Systems to 1:13.3.1.3.2

-delete & replace- section 9.7.4.1 **Portable Fire Extinguishers**: Portable fire extinguishers shall be located, installed, inspected and maintained in accordance with NFPA 1 section 13.6.

-add- section 9.9.1 **Carbon Monoxide Detection**: Where required by another section of this *Code* carbon monoxide alarms (detectors) shall be installed in accordance with NFPA 720, Standard for the Installation of Carbon Monoxide Warning (CO) Equipment in Dwelling Units, 2005 edition. NFPA 720 covers the selection, application, installation, location, testing and maintenance of carbon monoxide warning equipment in all buildings in which people sleep. [*section 720:1.1.2 is amended by this section*]

-add- section 9.9.2 **Power for Carbon Monoxide Alarms**: All newly installed carbon monoxide alarms (detectors) in multiple unit dwellings, lodging or rooming houses, hotels and dormitories, or other buildings in which people sleep, shall be directly wired to a non-dedicated electrical branch circuit for the building and by battery. Carbon monoxide detectors in existing one-two family dwellings shall be permitted to be powered by any approved source. [*for existing construction see section 7 for transition effective date*]

-add- section 12.3.5.4 New Assembly Occupancies: In addition to the fire sprinkler requirements of 101:12.1.6 & 101:12.3.5 all assembly occupancies where the occupant load exceeds 100, identified as bars, dance halls, discotheques, **nightclubs** or where festival seating is used, shall be protected throughout by an approved, supervised, automatic fire sprinkler system.

-cross-reference- section 13.1 Permit for Place of Assembly with Change of Ownership to 1:4.5.7.3

-add- section 13.3.5.4 Existing Assembly Occupancies: In addition to the fire sprinkler requirements of 101:13.1.6 & 101:13.3.5 all assembly occupancies where the occupant load exceeds 100, identified as bars, dance halls, discotheques, **nightclubs** or where festival seating is used, shall be protected throughout by an approved, supervised, automatic fire sprinkler system (*see section 7 for transition effective date)*

[*Bars, dance halls, discotheques, nightclubs and the use of festival seating (where no seating other than the floor is provided for the audience) are characterized by some or all of the following: a high density of people, alcohol consumption, late operating times, live or recorded entertainment, dance areas, low lighting levels and stage or platform areas for performing. A theater or opera house with fixed seating is not classified under this section*]

-delete & replace- section 14.7.2.2(1) Emergency Egress and Relocation Drills: Not less than one emergency egress and relocation drill, in accordance with the school's emergency preparedness plan, shall be conducted every month the facility is in session.

-delete & replace- section 15.2.1.2 Student Occupied Space: Rooms normally occupied by preschool, kindergarten or first grade students shall be located on a level of exit discharge, unless otherwise permitted by 15.2.1.4. Rooms with 4 or fewer students, where the ratio of students to teachers or aides does not exceed 2:1 at any time, are not considered normally occupied by students in regards to this section.

-delete & replace- section 15.7.2.2(1) Emergency Egress and Relocation Drills: Not less than one emergency egress and relocation drill, in accordance with the school's emergency preparedness plan, shall be conducted every month the facility is in session.

-add – section 16.3.4.6 **Carbon Monoxide Detection in New Daycare**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in the immediate vicinity of each separate sleeping area.

-add – section 17.3.4.6 **Carbon Monoxide Detection in Existing Daycare**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in the immediate vicinity of each separate sleeping area.

-add – section 18.3.4.6 **Carbon Monoxide Detection in New Health Care**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in each nursing station.

-add – section 19.3.4.6 **Carbon Monoxide Detection in Existing Health Care**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in each nursing station.

-delete & replace- section 19.3.5.1 **Existing Health Care**: Existing health care facilities shall be protected throughout by an approved supervised automatic fire sprinkler system installed in accordance with section 9.7.

-add – section 22.3.4.5 **Carbon Monoxide Detection in New Detention and Correctional Facilities**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in control rooms used by the facility.

-delete- section 22.4.4 Renovations for Existing Non-sprinklered Detention and Correctional Facilities

-add – section 23.3.4.5 **Carbon Monoxide Detection in Existing Detention and Correctional Facilities**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in control rooms used by the facility.

-delete and replace- section 23.3.5.2 **Existing Detention & Correctional**: Existing detention & correctional facilities classified as Use Condition II, III, IV or V shall be protected throughout by an approved supervised automatic fire sprinkler system installed in accordance with section 9.7.

-add- section 24.1.1.1.1 One & Two Family Dwellings used for **Transient Lodging**: A building that provides sleeping accommodations for a total of more than 6 people on a transient basis shall be classified as a lodging or rooming house or a hotel or dormitory under this code.

-add- section 24.2.2.3.1 Existing Means of Escape: The clear opening of an existing means of escape (***escape window***) under 24.2.2.3 (C) shall be permitted to be not less than 5.0 square feet.

-add- section 24.2.5.7 **Stair riser heights and tread depths**: Maximum riser heights of 7 ¾ in. and minimum tread depths of 10 in. shall be permitted in new construction.

-add – section 24.3.4.4 **Carbon Monoxide Detection, One-Two Family Dwellings**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 outside of each separate sleeping area in the immediate vicinity of the bedrooms. An additional carbon monoxide alarm (detector) shall be installed in any sleeping room that contains a fuel-burning appliance.

[***Manufactured housing*** *that is built on a chassis to conform to the Housing and Urban Development (HUD) Standard are preempted by that federal standard and not subject to additional requirements under this Code. Manufactured housing built to the HUD standard has an identification plate. Smoke detectors installed in accordance with NFPA 501:5.8 are considered in compliance with Title 9 V.S.A. Chapter 77. An owner may contact the U.S. Department of Housing and Urban Development (HUD) in Washington, D.C. at 1-800-927-2891 or the Consumer Assistance Program of the Vermont Office of Attorney General at 1-800-649-2424 for additional information.*]

-delete & replace- section 24.5.1.2 Unvented Fuel-fired Heaters: Unvented room heaters and unvented fireplaces shall not be used.

-add- section 24.6 **Subdivision of Building Spaces in One-Two Family Dwellings**: New one-two family dwellings shall be provided with dwelling unit separation in accordance with 30.3.7.

-add- section 26.1.1.1.1 **Small Lodging & Rooming Houses**: A building that provides sleeping accommodations for a total of 6 or fewer persons, and is occupied by the proprietor, may be classified as a one and two family dwelling by the AHJ.

-add – section 26.3.3.5.4 **Carbon Monoxide Detection, Lodging & Rooming**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 outside of each separate sleeping area in the immediate vicinity of the bedrooms. An additional carbon monoxide alarm (detector) shall be installed in any bedroom that contains a fuel-burning appliance.

-delete- section 26.3.5.2 Exception for Automatic Sprinkler Protection for New Lodging & Rooming Houses with Direct Access

-delete & replace- section 26.5.2.2 Unvented Fuel-fired Heaters: Unvented room heaters and unvented fireplaces shall not be used.

-add – section 28.3.4.6 **Carbon Monoxide Detection in New Hotels & Dormitories**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in any section of corridor or common area that is in the immediate vicinity of sleeping rooms, or where there is no corridor, in each sleeping room. An additional carbon monoxide alarm (detector) shall be installed in any sleeping room that contains a fuel-burning appliance.

-delete - section 28.3.5.2 Exception for Automatic Sprinkler Protection for New Hotels & Dormitories with Direct Access

add- section 29.3.4.4 Detection for Existing Hotels & Dormitories: A corridor smoke detection system in accordance with section 9.6 shall be installed in existing hotels & dormitories other than those protected throughout by an approved supervised automatic sprinkler system in accordance with section 9.7.

-add – section 29.3.4.6 **Carbon Monoxide Detection in Existing Hotels & Dormitories**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in any section of corridor or common area that is in the immediate vicinity of sleeping rooms, or where there is no corridor, in each sleeping room. An additional carbon monoxide alarm (detector) shall be installed in any sleeping room that contains a fuel-burning appliance.

-delete & replace- section 30.3.4.5.2 **Smoke Alarms in Sleeping Rooms**: Approved smoke alarms shall be provided in each sleeping room in accordance with 9.6.2.10.

-add – section 30.3.4.6 **Carbon Monoxide Detection, New Apartment Buildings**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 outside of each separate sleeping area in the immediate vicinity of the bedrooms. An additional carbon monoxide alarm (detector) shall be installed in any bedroom that contains a fuel-burning appliance.

-delete & replace- section 30.5.2.2 Unvented Fuel-fired Heaters: Unvented room heaters and unvented fireplaces shall not be used.

-add – section 31.3.4.6 **Carbon Monoxide Detection, Existing Apartment Buildings**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 outside of each separate sleeping area in the immediate vicinity of the bedrooms. An additional carbon monoxide alarm (detector) shall be installed in any bedroom that contains a fuel-burning appliance.

-delete & replace- section 31.5.2.2 Unvented Fuel-fired Heaters: Unvented room heaters and unvented fireplaces shall not be used.

-add- section 32.1.1.2 **Assisted Living Facilities**: In addition to the requirements of this chapter a facility licensed under the Department of Aging & Disabilities Rules for Assisted Living Residences shall comply with the following:
(1) All facilities shall be fully sheathed (15 min. fire rating) in addition to having complete automatic fire sprinkler protection.
(2) Emergency lighting shall be provided for the means of egress and in the vicinity of doors equipped with delayed egress locks.
(3) & (4) (reserved)
(5)The fire alarm system shall provide emergency forces notification.
(6) All automatic fire sprinkler systems shall be electronically supervised.
(7) (reserved)
(8) Corridors for large facilities shall not be less than 48”.
(9) Subdivision of building spaces in accordance with 101:18.2.2.5 shall be provided in common areas of large facilities using the same criteria as used for limited care facilities (15 square feet per resident).

-add – section 32.1.1.2.1 **Carbon Monoxide Detection in New Residential Care**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in any section of a corridor or common area that is in the immediate vicinity of sleeping rooms.

-delete & replace- section 32.2.3.5.1 **New Residential Board & Care**: All new residential board & care facilities shall be protected throughout by an approved supervised automatic fire sprinkler system installed in accordance with section 9.7.

-delete- section 32.2.3.5.2 Exception for Sprinkler Protection for New Small Board and Care Facilities

-add – section 33.1.1.2.1 **Carbon Monoxide Detection in Existing Residential Care**: Carbon Monoxide alarms (detectors) shall be installed in accordance with section 9.9.1 and 9.9.2 in any section of corridor or common area that is in the immediate vicinity of sleeping rooms.

-delete & replace- section 33.2.3.4.3.1 **Smoke Alarms in Sleeping Rooms**: Approved smoke alarms shall be provided in each sleeping room in accordance with 9.6.2.10.

-delete- section 33.2.3.4.3.5 Exception for Smoke Alarms in Residential Care with Sprinkler Protection

-delete- section 33.2.3.4.3.6 Exception for Smoke Alarms in Residential Care with Sprinkler Protection – Battery Operated -

-add- section 38.2.4.2.1 **Single exit for New Small Business**: A single exit shall be permitted to be- unenclosed in two-story buildings when the travel distance does not exceed 75' and all areas opening to the exit access stairs are provided with smoke alarms- in accordance with 9.6.2.10.

-add- section 38.3.1.1(3) **Protection of Vertical- Opening in New Small Business**: Unenclosed vertical openings shall be permitted to be unenclosed- in two-story buildings when the travel distance does not exceed 75' and all areas opening to the exit access stairs are provided with smoke alarms in accordance with 9.6.2.10. -

-add- section 39.2.4.2.1 **Single Exit for Existing Small Business**: A single exit shall be permitted to- be unenclosed in two-story buildings when the travel distance does not exceed 75' and all areas opening to the exit access stairs are provided with smoke alarms in accordance with 9.6.2.10.

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-add- section 39.3.1.1 (4) **Exception for Protection of Vertical Openings for Existing Small Business**: Exit access stairs shall be permitted to be unenclosed in two-story buildings when the travel distance does not exceed 75' and all areas opening to the exit access stairs are provided with smoke alarms in accordance with 9.6.2.10.

(c) National Board of Boiler and Pressure Vessel Inspectors, **National Board Inspection Code**, Part RA – RE, Appendix 1-9 and A-K, 2004 edition

-delete & replace- section I-3724(a) **Low Water Cutoff:** Each automatically fired low pressure hot water boiler shall have an automatic low-water fuel cutoff which has been designed for hot water service, and it shall be so located as to automatically cut off the fuel supply when the surface of the water falls to the level established in I-3724(b).

(d) International Code Council, **International Building Code (IBC)**, 2003 edition, including those standards referenced in Chapter 35 to the prescribed extent of each reference by adopted sections of the IBC. The IBC is adopted to the extent necessary to ensure compliance with the performance requirements of this *Code* and the intent of this *Code* regarding safeguarding of people and property in case of fire, explosion, dangerous structural conditions and the generation of carbon monoxide.

-delete- chapter 1 Administration except for section 106.3.4 and the following sections:

-delete & replace- section 101.4 Referenced Codes: Where referenced under the IBC any reference to the:
* **ICC Electrical Code**, shall be to the National Electrical Code, NFPA 70, as adopted by the Electricians Licensing Board
* **International Fuel Gas Code**, shall be to the National Fuel Gas Code, NFPA 54, 2002 edition, as adopted under this *Code*
* **International Mechanical Code**, shall be to the Uniform Fire Code, NFPA 1, 2003 edition, including NFPA 90A, as adopted under this *Code*
* **International Plumbing Code** shall be as adopted by the Plumbers Examining Board
* **International Property Maintenance Code**, shall be to the Uniform Fire Code, NFPA 1, 2003 edition and the Life Safety Code, NFPA 101, 2003 edition, as adopted under this *Code*
* **International Fire Code**, shall be to the Uniform Fire Code, NFPA 1, 2003 edition, as adopted under this *Code*
* **International Energy Code**, shall be to the Vermont Guidelines for Energy Efficient Construction, as published by the Vermont Department of Public Service, and shall only apply to new state-funded buildings or additions
* **International Residential Code**, or to R-3 Occupancy Classification for one & two family dwellings, shall be to the Life Safety Code, NFPA 101, 2003 edition as adopted under this *Code*

-delete & replace- section 105 Construction Permits: Permits shall be obtained in accordance with section 4 of the Vermont Fire & Building Safety Code

-delete & replace- section 308.2 Group I-1, Residential Board & Care Facilities: Assisted Living Facilities and similar use: Residential care facilities, assisted living facilities and similar use in which three or more clients receive care shall be classified and regulated in accordance with the Life Safety Code, NFPA 101, and the IBC, chapter 16.

-delete & replace- section 308.5 Day Care Facilities: Day care facilities in which four or more clients receive care shall be classified and regulated in accordance with the Life Safety Code, NFPA 101, and the IBC, chapter 16.

-delete & replace- section 310.1 R-3 Detached **one & two Family Dwellings**: Detached one & two family dwellings shall be classified and regulated in accordance with the Life Safety Code, NFPA 101.

-delete & replace- section 415.9.1 Protection of **Semiconductor Fabrication Facilities**: In addition to requirements set elsewhere in this code semiconductor fabrication facilities shall be in accordance with the Uniform Fire Code, NFPA 1, and NFPA 318.

- Construction Correlation Table -

96 NBC	**03 IBC**	**101/1 NFPA**
1A	none	I(443)
1B	IA	I(332)
2A	IB	II(222)
2B	IIA	II(111)
2C	IIB	II(000)
3A	IIIA	III(211)
3B	IIIB	III(200)
4	IV	IV(2HH)
5A	VA	V(111)
5B	VB	V(000)

-delete & replace- section 506.2.2 Open Space for Area Increase: Such open space shall be either on the same lot or dedicated for public use, clear and unobstructed at all times, usable for fire department operations and accessed from a street or fire department access road in accordance with NFPA 1: chapter 18.

-add- section 507.10 Open Space for Unlimited Area Buildings: Open space required under section 507 shall be either on the same lot or dedicated for public use, clear and unobstructed at all times, usable for fire department operations and accessed from a street or fire department access road in accordance with NFPA 1: chapter 18.

-delete & replace- section 705 **Fire Walls**: The design and construction of new firewalls shall be in accordance with NFPA 1:12.3 and NFPA 221. The minimum fire resistance ratings of firewalls located in a building with a complete automatic sprinkler system shall be two hours and the minimum fire resistance ratings of firewalls located in a building without a complete automatic sprinkler system shall be three hours.

-delete & replace- chapter 8 Interior Finishes: Interior finishes shall be in accordance with the Life Safety Code, NFPA 101, as adopted under this *Code.*

-delete & replace- chapter 10 Means of Egress: Means of Egress shall be in accordance with the Life Safety Code, NFPA 101, as adopted under this *Code.*

-delete & replace- chapter 11 **Accessibility**: All new construction and alterations shall be in accordance with the “Accessibility in Public Buildings - Rules for New Construction and for Alterations to Existing Buildings” as adopted by the Vermont Access Board and 20 V.S.A. 2907 regarding residential construction.

-delete- chapter 12 Interior Environment except for section 1209 Access to Unoccupied Spaces

-delete- & replace- chapter 13 **Energy Efficiency**: New state-funded buildings or additions shall be designed in accordance with the Vermont Guidelines for Energy Efficient Construction, as published by the Vermont Department of Public Service. [*The Department of Public Service provides technical assistance and expert advice regarding the energy standard requirements for new construction. This includes criteria that builders may use in lieu of computer or systems analysis of the building. For additional information contact the Vermont Department of Public Service at 1-888-373-2255.*]

-add- section 1608.2.1 Local **Snow Load**: The Minimum Ground Snow Load Map and the Average Yearly Snowfall Map shall be used in determining the ground snow load. [*The snow load map is located in the Annex to this Code*]

-add- section 1608.3.6 Minimum **Snow Load**: The resultant flat roof snow load on a roof with a slope equal to or less than 5 degrees shall not be less than 40 pounds/square foot.

-delete & replace- sections 2111 through 2113: Masonry Fireplaces, Heaters and Chimneys: Masonry fireplaces, heaters and chimneys shall be in accordance with the Standard for Chimneys, Fireplaces, Vents and Solid Fuel-Burning Appliances, NFPA 211, as adopted under this *Code*

-delete & replace- chapter 27 **Electrical**: Electrical components, equipment and systems shall be in accordance with the National Electrical Code, NFPA 70, as adopted by the Electricians’ Licensing Board

-delete & replace- chapter 28 **Mechanical Systems**: Mechanical equipment and systems shall be installed in accordance with the Uniform Fire Code, NFPA 1, including NFPA 90A as adopted under this *Code.*

-*delete & replace*- chapter 29 Plumbing Systems: Plumbing work is regulated under the International Plumbing Code as adopted by the Plumbers Examining Board.

-*delete & replace*- chapter 30 **Elevators** and Conveying Systems, except sections 3002.1, Hoistway Enclosure Protection, 3004, Hoistway Venting and 3006, Machine Room Enclosure: Elevator and conveyance work is regulated under the Elevator Safety Rules as adopted by the Elevator Safety Review Board.

-*delete*- section 3108 Radio and television Towers

-*delete*- section 3109 Swimming Pool Enclosure and Safety Devices

-*delete*- chapter 32 Encroachments into the Public Right-of-Way

-*delete &replace* – chapter 33 Safeguards During Construction: Safety during construction shall be in accordance with the Standard for Safeguarding Construction, Alteration and Demolition Operations, NFPA 241, as adopted under this *Code.*

-*delete & replace*- chapter 34 **Existing Buildings**: Existing buildings shall be in accordance with section 3403.2, the Life Safety Code and the Uniform Fire Code. An existing building plus additions shall comply with the height and area provisions of Chapter 5.

Section 3.
Boiler and Pressure Vessel Inspection

(a) A boiler is defined as a closed vessel in which water is heated, steam is generated, steam is super heated, or any combination thereof, under pressure or vacuum by the direct application of heat from the combustion of fuel or from electricity. The term includes a fired unit for the heating or vaporizing of liquids other than water where the unit is separate from a processing system and is complete within itself. An unfired pressure vessel is defined as a container of pressure obtained from an external source that exceeds 15 psi. This section shall apply to all boilers, and pressure vessels identified in the National Board Inspection Code except:
(1) A boiler or pressure vessel located on a common carrier subject to regulations under the Surface Transportation Board, Department of Transportation, Federal Railroad Administration or Nuclear Regulatory Commission.
(2) Pressure containers that are integral parts or components of rotating or reciprocating mechanical devices such as pumps, compressors, turbines, generators, engines and hydraulic or pneumatic cylinders where the primary design consideration and /or stress is derived from the functional requirements of the device.
(3) Hot **water heaters** and portable water storage tanks with a heat input of less than 200,000 BTU/HR, water temperature less than 210 degrees (F) and less than 120 gallons aggregate water capacity. Units otherwise exempted under this section shall be equipped with approved pressure/temperature safety relief devices in accordance with NBIC I 3837.
(4) Steam cleaners or coil type boilers without steam space where water flashes into steam when manually released through a nozzle for cleaning machinery, equipment, etc.; when the water capacity is less than 6 gallons and the water temperature less than 350 degrees (F). Units otherwise exempted under this section shall be equipped with approved pressure/temperature safety relief devices in accordance with NBIC.

(b) All boilers and pressure vessels shall be manufactured, constructed and assembled in accordance with the appropriate American Society of Mechanical Engineers **(ASME) standards,** or equivalent standard recognized by the National Board of Boiler & Pressure Vessel Inspectors, in place at the time of manufacture. The manufacturer of a boiler or pressure vessel shall register the type of unit with the National Board of Boiler and Pressure Vessel Inspectors.

(c) The owner or person installing a boiler or pressure vessel shall report to the AHJ the location, type, capacity, age and date of installation of any boiler or pressure vessel.

(d) Prior to being placed in service **any boiler or pressure vessel shall be inspected** by a commissioned inspector. When the boiler or pressure vessel is found to be in compliance with this *Code* the commissioned inspector shall attach an identification number, approved by the AHJ, and an initial inspection certificate issued by the AHJ. The inspection certificate shall be posted at the site of operation. The identification number, initial inspection by a commissioned inspector and operating certificate shall not be required for boilers designed to heat individual dwelling units in buildings containing less than 6 dwelling units.

(e) The **periodic inspection of boilers and pressure vessels** shall be performed by a commissioned inspector at intervals listed in this section. A commissioned inspector may require additional external (an inspection made when a boiler or pressure vessel is fully intact so all safety features can be inspected) or internal (an inspection made when a boiler or pressure vessel is shut down and handholes, manholes or other inspection openings are opened for inspection of the interior) inspections when unsafe conditions or operations are observed or suspected. The AHJ may order the owner or user to stop operation of a boiler or pressure vessel operating in violation of this *Code.*
(1) Each high pressure power boiler in which steam is generated at a pressure of more than 15 pounds per square inch shall be inspected both internally and externally while not under pressure on an annual basis, and externally, while under pressure, approximately six months from the internal inspection.
(2) Each low-pressure hot water heating boiler installed to operate at pressures not to exceed 160 pounds per square inch and/or temperatures not exceeding 250 degrees (F), and each steam heating boiler operating at a pressure not exceeding 15 pounds per square inch, shall be inspected externally, and internally where construction permits, every two years. An inspection shall not be required for boilers designed to heat individual dwelling units in buildings containing less than 6 dwelling units.
(3) Each pressure vessel greater than 5 cubic feet and operating with a relieving pressure greater than 125 pounds per square inch shall be inspected externally, and internally where construction permits, every three years. An internal inspection is not required for a rubber lined pressure vessel.

(f) An employee of an insurance company, licensed to insure boilers and pressure vessels in Vermont, shall obtain a current Vermont commission to inspect boilers and pressure vessels prior to conducting any inspections. A current certification from the National Board of Boiler and Pressure Vessel Inspectors is required to obtain a Vermont commission. A Vermont commission may be revoked or suspended for violation or misrepresentation of responsibilities established under this *Code*. A person who has a Vermont commission revoked or suspended shall be given written notification and the opportunity for a hearing following due process.

(g) An employee of an insurance company, licensed to insure boilers and pressure vessels in Vermont, who has obtained a Vermont commission, and/or the insurance company, licensed to insure boilers and pressure vessels in Vermont shall:
(1) Inspect all boilers and pressure vessels insured by the insurance company in accordance with this *Code* and at time frames established under this *Code.*
(2) Report the results of all inspections to the AHJ within 30 days of the inspection in a format approved by the AHJ.
(3) Notify the AHJ of new boilers or pressure vessels insured, insurance cancelled or not renewed or refused within 30 days.
(4) Participate in training as may be directed by the AHJ.
(5) Not engage in the sale of, or have any interest in, any appliance or device related in any way to the construction, operation or maintenance of boilers and pressure vessels covered under this *Code.*

(h) The owner, user or commissioned inspector shall immediately **report any accident, incident or explosion** involving a boiler or pressure vessel that involves personal injury to the AHJ at 1-800-347-0488 and secure the scene to prevent any change that would hamper the investigation of the incident. Where the accident, incident or explosion does not involve personal injury the report shall be made within 48 hours.

(i) The insurance company of record shall pay a fee of $20.00 to the Division of Fire Safety for each **inspection certificate** or periodic inspection sticker

Section 4.
Application for a Construction Permit

(a) The owner, or a designated representative, of a building or premises shall obtain a construction permit before beginning any construction, addition, alteration, demolition or installation of fixed building equipment at the building site unless specifically waived by the AHJ.

(b) To obtain a construction permit the applicant shall:

(1) Complete a Construction Permit Application form and submit it along with the required construction permit fee to the Division of Fire Safety regional office.
(2) Provide construction documents relating to the construction work and equipment under consideration unless specifically waived by the AHJ based on the size, use, occupancy or complexity of the work.
(3) For buildings where the applicant is requesting special consideration for a **historic building, documentation** shall be included on the historic designation of the building, including identification and evaluation of historic adjacent structures and site elements such as sheds, walkways, and fencing; historic construction features such as sheathing, facade or roofing materials, chimneys, skylights, cornices or molding, windows or doors, wainscoting, cabinets and finishes; and historic spaces such as archways, lobbies or rooms which are important to the understanding and application of the building.

(c) The **construction documents shall include an express certification that the design meets or exceeds this *code*** as indicated in the following sections. Construction documents stamped and signed by an architect or professional engineer consistent with the professional licensing and registration laws of Vermont meets the intent of this section without additional certification.
(1) For new state-funded buildings and additions; certification indicating compliance with the "Vermont Guidelines for Energy Efficient Commercial Construction" as published by the Department of Public Service.
(2) For new buildings and additions; certification indicating the building is designed to prevent normally anticipated unstable or dangerous structural conditions.

(d) Plans required under this *Code* shall be drawn to scale, using customary inch-pound units and English language, and shall be sufficiently clear, comprehensive, detailed and legible when submitted to the AHJ so that, together with any accompanying specifications and data, the AHJ can readily determine whether or not the proposed building, addition, or alteration, and all proposed building equipment will conform to this *Code.*

(e) The AHJ shall review the application for a construction permit and the construction documents where applicable and shall issue a permit, a conditional permit with specific terms and conditions, or deny the application. The AHJ may require additional information before issuing, or denying the application for a construction permit. Any conditions of the permit or reasons for denial of the permit shall be transmitted to the applicant in writing.

(f) The AHJ may provide consultation or preliminary plan review for proposed construction to identify high priority code issues when deemed warranted by the significance or complexity of the project.

(g) A construction permit shall expire if the work authorized under the permit is not commenced, or is suspended or abandoned, for a time period of 12 months.

(h) Construction permit fees are established by the Vermont Legislature under Title 20 V.S.A. section 2731. The current construction permit fees are available on the Division's website or by contacting any office of the Division.
(1) The Commissioner or designated representative may rebate up to $2,000 of the construction permit fee paid the department toward the cost of a qualified fire sprinkler system installed in an existing building in a designated downtown area.
(2) In the case of abandonment or discontinuance of a building project involving a construction permit fee greater than $150 the construction permit fee may be refunded, upon written request to the AHJ, prorated on construction work, services, reviews and inspections conducted prior to such abandonment. Such request shall be received within 12 months of the date that the construction permit was issued.
(3) The AHJ may refuse to issue a construction or occupancy permit if the owner or a designated representative owes the Department fees or penalties.

(j) The AHJ shall be authorized to require the owner to engage, and designate on the construction permit application, a registered design professional who shall act as the **design professional in responsible charge** in accordance IBC 106.3.4, who shall be responsible for reviewing and coordinating submittal documents prepared by others for compatibility with the approved design of the building.

(k) The AHJ shall be authorized to order all, or part of, work regulated under this *Code* to stop when the work is unsafe or being performed contrary to the provisions of this *Code.*

Section 5.
Variance, Exemption and Reconsideration

(a) The Commissioner may grant a variance approving a different solution to compliance that meets the intent of this code, or may exempt a portion of a building, or equipment including non-standard boilers and pressure vessels, from the requirements of this Code. It is the policy of the Commissioner that whenever possible the determination of a variance or exemption request be made by the Regional Managers or Chief Fire Prevention Officer.

(b) In order for a variance or exemption request to be reviewed the owner or designated representative shall submit:

1. Evidence that the proposed or existing building or premises is not in compliance with this Code.

2. Evidence, letters, statements, test results, construction documents, computations, chemical and physical properties or other supporting information as prepared by licensed or certified professionals that is required to justify the request.

3. Evidence that strict compliance with the Code would entail practical difficulty, unnecessary hardship or otherwise found unwarranted.

4. Evidence that any such variance or exemption secures the public safety and health and that the methods, means or practices proposed provide equal protection of the public safety and health.

(c) Review of the variance or exemption request shall consider evidence that the code or standard from which the variance or exemption is sought has not been promulgated as a rule or standard under the Vermont Occupational Safety and Health Act.

(d) The determination on the variance or exemption request shall be made in writing to the applicant and shall advise the applicant of the reconsideration process as contained in Section (e).

(e) The Director may reconsider an interpretation or decision made by a designated representative pursuant to this Section. To request reconsideration the owner or designated representative shall submit a written request including:

1. Evidence the proposed or existing building or premises is not in compliance with this Code.

2. Evidence, letters, statements, test results, construction documents or other supporting information as required to justify the request.

3. Evidence that the true intent of the Code has been incorrectly interpreted, or the provisions of the Code do not fully apply; or the decision is unreasonable or arbitrary as it applies to alternatives or new materials.

(f) The request for reconsideration shall be submitted no later than 30 days after receiving the variance or exemption decision.

(g) A request for variance, exemption, or reconsideration shall not relieve a person from complying with this *Code*, permit or occupancy requirements, unless the Commissioner expressly authorizes an extension of compliance period pending review of the request.

(h) A request for a variance relating to access to a public building for people with disabilities shall be referred for decision to the Access Board established under Title 20 V.S.A. chapter 174.

(i) A request for a variance from this *Code* for historical buildings that is not resolved under section 5(a) shall be determined by the Historic Variance Appeals Board as established by 20 V.S.A. 2732.

Section 6.
Municipal Enforcement and Coordination

(a) Each municipality shall provide information regarding building permits issued by the municipality to the AHJ upon request.

(b) The Commissioner may assign the responsibility for the enforcement of all or part of these rules to municipalities that meet the qualifications established in 20 V.S.A. sections 2736 and 2884.

(c) Any fire, building or similar code standards adopted by any municipality shall be consistent with the standards adopted under this *Code*.

Section 7.
Effective Dates and Severability

(a) (a) These rules shall take effect October 22, 2005 and shall be known as the Vermont Fire & Building Safety Code - 2005.

(b) (b) To achieve an orderly transition for compliance with these rules:

- NFPA 1 section 29.1.3 shall take effect October 1, 2006
- NFPA 101 section 9.9.2 shall take effect October 1, 2007
- NFPA 101 section 13.3.5.4 shall take effect October 1, 2007 where the occupant load exceeds 300
- NFPA 101 section 13.3.5.4 shall take effect October 1, 2009 where the occupant load exceeds 100

- (c) This *Code* shall not require changes in the construction documents or construction of a building or portions of a building for which a construction permit has been issued and construction has started within 90 days of the effective date of this *Code,* or as otherwise approved by the AHJ, provided that the building or portions of the building meet or exceed the requirements for existing buildings under this *Code*.

(d) In the event any part or provision of these rules is held to be illegal, this shall not have the effect of making void or illegal any of the other parts or provisions of these rules. Under section 2 of this *code* certain Vermont amendments have been cross-referenced for clarity and ease of use. Failure to cross-reference an amendment does not affect the enforcement of that amendment.

(e) Upon adoption of the Vermont Fire & Building Safety Code - 2005 the “Vermont Fire Prevention and Building Code – 1999” and the “1990 Vermont Boiler & Pressure Vessel Rules” are repealed.

Annex I – Excerpts from Vermont Law Pertaining to the Vermont Fire & Building Safety Code

Chapter 173: PREVENTION AND INVESTIGATION OF FIRES

§ 2729. General provisions

(a) A person shall not build or cause to be built any structure that is unsafe or likely to be unsafe to other persons or property in case of fire or generation and leakage of carbon monoxide.

(b) A person shall not maintain, keep or operate any premises or any part thereof, or cause or permit to be maintained, kept, or operated, any premises or part thereof, under his or her control or ownership in a manner that causes or is likely to cause harm to other persons or property in case of fire or generation and leakage of carbon monoxide.

(c) On premises under a person's control, excluding single family owner-occupied houses and premises, that person shall observe rules adopted under this subchapter for the prevention of fires and carbon monoxide leakage that may cause harm to other persons or property.

(d) Any condominium or multiple unit dwelling using a common roof, or row houses so-called, or other residential buildings in which people sleep, including hotels, motels, and tourist homes, excluding single family owner-occupied houses and premises, whether the units are owned or leased or rented, shall be subject to the rules adopted under this subchapter and shall be provided with one or more carbon monoxide detectors, as defined in 9 V.S.A. section 2881(3), properly installed according to the manufacturer's requirements..

§ 2730. Definitions

(a) As used in this subchapter, "**public building**" means:

(1)(A) a building owned or occupied by a public utility; hospital; school; house of worship; convalescent center or home for the aged, infirm, or disabled; nursery; kindergarten; or day care;

(B) a building in which two or more persons is employed, or occasionally enter as part of their employment or are entertained, including private clubs and societies;

(C) a cooperative or condominium; [*A condominium is described as a building or complex in which units of property, such as apartments, are owned by individuals and common parts of the property, such as the grounds and building structure, are owned jointly by the unit owners. A unit in such a complex.*]

(D) a building in which people rent accommodations, whether overnight or for a longer term;

(E) a restaurant, retail outlet, office or office building, hotel, tent, or other structure for public assembly, including outdoor assembly, such as a grandstand;

(F) a building owned or occupied by the state of Vermont, a county, a municipality, a village, or any public entity, including a school or fire district.

(2) Use of any portion of a building in a manner described in this subsection shall make the entire building a "public building" for purposes of this subsection. For purposes of this subsection, a "person" does not include an individual who is directly related to the employer and who resides in the employment-related building.

(b) The term "public building" does not include:

(1) an owner-occupied single family residence, unless used for a purpose described in subsection (a) of this section;

(2) a family residence registered as a day care home under chapter 35 of Title 33, or specifically exempted from registration by subdivision 3502(b)(1) of Title 33;

(3) farm buildings on a working farm or farms. For purposes of this subchapter and subchapter 3 of this chapter, the term "working farm or farms" means farms with fewer than the equivalent of 10 full-time employees who are not family members and who do not work more than 26 weeks a year. In addition, the term means a farm or farms:

(A) whose owner is actively engaged in farming; or

(B) if the farm or farms are owned by a partnership or a corporation, one which includes at least one partner or principal of the corporation who is actively engaged in farming;

(C) where the farm or farms are leased, the lessee is actively engaged in farming. The term "farming" means:

(i) the cultivation or other use of land for growing food, fiber, Christmas trees, maple sap, or horticultural and orchard crops;

(ii) the raising, feeding, or management of livestock, poultry, equines, fish, or bees;

(iii) the production of maple syrup;

(iv) the operation of greenhouses;

(v) the on-site storage, preparation, and sale of agricultural products principally produced on the farm. Notwithstanding this definition of farming, housing provided to farm employees other than family members shall be treated as rental housing and shall be subject to the provisions of this chapter. In addition, any farm building which is open for public tours and for which a fee is charged for those tours shall be considered a public building.

(4) a single family residence with an **accessory dwelling unit** as permitted under subdivision 4406(4)(D) of Title 24. [*reference 24 vsa 4412(E) An accessory dwelling unit is an efficiency or one-bedroom apartment that is clearly subordinate to a single-family dwelling, and has facilities and provisions for independent living, including sleeping, food preparation, and sanitation, and does not exceed 30 percent of the total habitable floor area of the single-family dwelling.*]

(c) For the purpose of this subchapter, subchapter 3 of this chapter, and chapter 174 of Title 20, the words "premises," "building," and "structure," or any part thereof shall mean "public building" as defined in this section.

[*Buildings classified as public buildings and owned by* ***a federal agency*** *are not exempt from state and municipal codes but there are limitations on how this Code is applied. 40 U.S.C.A, section 3312 requires that a federal agency consult with local code officials, submit plans for review and permit inspection of the construction project. The federal agency is required to give due consideration to any recommendations made by the local code official and build in compliance with nationally recognized building, electrical, fire, life safety and plumbing codes. A federal agency is exempt from any fees and no enforcement action can be brought against the federal agency for failure to comply with the law.*]

(d) "**Historic building**" or "historic structure" means any structure which has been listed in the National Register of Historic Places or the state register of historic properties or which has been determined to be historically significant by the Vermont advisory council on historic preservation or which meets the standards adopted by the division for historic preservation pursuant to subsection 723(a) of Title 22.

(e) The phrase "damage or destroy the historic architectural integrity of the historic building or structure" means to have an undue adverse impact on historically significant features of the historic architectural integrity of the building.

§ 2731. Rules; inspections; variances

(a) The commissioner is authorized to adopt rules regarding the construction of buildings, maintenance, and operation of premises, and prevention of fires and removal of fire hazards, and to prescribe standards necessary to protect the public, employees, and property against harm arising out of or likely to arise out of fire.

(b) The commissioner shall conduct inspections of premises to assure that the rules adopted under this subchapter are being observed and may establish priorities for enforcing these rules and standards based on the relative risks to persons and property from fire of particular types of premises. The commissioner may also conduct inspections to assure that buildings are constructed in accordance with approved plans and drawings.

(c) The following fire prevention and building code fees are established:

(1) The permit application fee for a construction plan approval shall be:

(A) based on **$4.50 per each $1,000.00** of the total valuation of the construction work proposed to be done for renovation to buildings constructed before 1983, but in no event shall the permit application fee exceed $135,000.00;

(B) based on $**5.50 per each $1,000.00** of the total valuation of the construction work proposed to be done for all other buildings, but in no event shall the permit application fee exceed $135,000.00.

(2) When an inspection is required due to the **change in use** of a public building, the fee shall be $25.00.

(3) The **proof of inspection fee** for fire suppression, alarm, detection, and any other fire protection systems shall be $10.00.

(d) The commissioner shall make all practical efforts to process permits in a prompt manner. The commissioner shall establish time limits for permit processing as well as procedures and time periods within which to notify applicants whether an application is complete.

(e) The commissioner may grant variances or exemptions from rules adopted under this subchapter where strict compliance would entail practical difficulty, unnecessary hardship, or is otherwise found unwarranted, provided that:

(1) any such variance or exemption secures the public safety and health; and

(2) any petitioner for such a variance or exemption can demonstrate that the methods, means, or practices proposed to be taken in lieu of compliance with the rule or rules provide, in the opinion of the commissioner, equal protection of the public safety and health as provided by the rule or rules; and

(3) the rule or rules from which the variance or exemption is sought has not also been adopted as a rule or standard under subchapters 4 and 5 of chapter 3 of Title 21; and

(4) any such variance or exemption does not violate any of the provisions of chapters 3 and 20 of Title 26 or any rules adopted thereunder.

(f) The commissioner shall, in state-funded buildings or new additions to state-funded buildings on which construction is begun after June 30, 2001, meet the standards contained in "The Vermont Guidelines for Energy Efficient Commercial Construction" as published in its most recent edition by the department of public service.

(h) A building owner or contractor engaged in an older and historic renovation project may propose innovative, performance-based alternatives in lieu of strict fire and building code compliance. The commissioner shall consider such alternatives and shall accept those that provide equivalent protection of the public safety and health. A decision to accept or deny a proposed alternative shall be in writing and explain the reasons for accepting or denying the alternative.

(i)(1) The department approves stamped architectural plans by issuing a plan review letter. If, upon final inspection, the department requires structural changes, additional life safety modifications, or state-mandated accessibility modifications, and the modifications or changes are not the result of design or construction changes by the owner, the owner or architect:

(A) may apply for a variance or exemption as provided in subsection (e) of this section, section 2732 of this title, and section 2902 of this title; and

(B) if the variance or exemption request is denied, upon the completion of the structural changes or additional life safety, or state-mandated accessibility modifications, as the case may be, may apply to the commissioner for a reimbursement of some or all of the plan review fee paid for the project.

(2) The decisions of the commissioner, pursuant to this subsection, shall be final. The commissioner shall adopt rules to carry out the provisions of this subsection. This subsection shall not apply to design or construction changes necessary to comply with an alternative method of life safety code or state-mandated accessibility compliance requested by the owner after the plan review.

§ 2732. Historic variance appeals board; variances; exemptions

(a) An historic variance appeals board is created. The board shall consist of the following three members: the commissioner of public safety or designee, who shall be chair; the state historic preservation officer or designee; and a representative of the Vermont historic preservation community appointed by the governor. A board member who is not a state employee shall be entitled to compensation and expenses as provided by section 1010 of Title 32.

(b) The board shall hear and determine all requests for variances or exemptions from the rules adopted by the commissioner under this subchapter for historic buildings and structures. A request for a variance or exemption may be granted where an applicant has demonstrated that strict compliance would entail practical difficulty, or unnecessary hardship, or would damage or destroy the historic architectural integrity of the historic building or structure, or is otherwise found unwarranted, provided that:

(1) any such variance or exemption secures the public safety and health;

(2) any petitioner for such a variance or exemption can demonstrate that the methods, means, or practices proposed to be taken in lieu of compliance with the rule or rules provide, in the opinion of the board, equal protection of the public safety and health as provided by rule or rules;

(3) the rule or rules from which the variance or exemption is sought have not also been adopted as a rule or standard under subchapters 4 and 5 of chapter 3 of Title 21; and

(4) any such variance or exemption does not violate any of the provisions of chapters 3 and 20 of Title 26 or any rules adopted thereunder.

(c) The board may permit a person seeking a variance or exemption to phase in compliance with the rules adopted under this subchapter in lieu of or in addition to granting the variance or exemption requested. The period of phased in compliance shall be reasonable but shall state a date by which compliance shall be achieved.

(d) Any person seeking a variance or exemption for work involving an historic building shall file a written request with the commissioner. The request shall describe the rule or rules from which the variance or exemption is sought, the reasons why a variance or exemption is sought, and a description as to how any alternative means of protecting the public safety and health is to be provided. The board shall meet and consider such requests within 15 working days of the request being filed with the commissioner. In deciding whether to grant or deny the request, the board shall take testimony or receive information from the applicant or his or her representatives, and from fire safety division staff. A decision of the board based on a majority vote of those members present shall be binding. The board shall issue a written determination granting or denying, in whole or in part, any variance or exemption request, or permission to phase in compliance, within 60 days of hearing the request. If a grant is conditional, the condition shall be clearly stated in writing. Failure to act on a request within 60 days shall be deemed approval of the request, provided that the public safety and health is not imminently threatened.

(e) The board may adopt, amend, or repeal procedural rules to carry out the provisions of this section.

(f) The board is attached to the department of public safety for administrative purposes.

(g) The board shall be subject to the requirements of subchapters 2 and 3 of chapter 5 of Title 1.

§ 2733. Orders to repair, rehabilitate, or remove structure

(a) Whenever the commissioner finds that premises or any part of them does not meet the standards adopted under this subchapter, the commissioner may order it repaired or rehabilitated. If it is not repaired or rehabilitated within a reasonable time as specified by the commissioner in his or her order, the commissioner may order the premises or part of them closed, if by doing so the public safety will not be imperiled; otherwise he or she shall order demolition and removal of the structure, or fencing of the premises. Whenever a violation of the rules is deemed to be imminently hazardous to persons or property, the commissioner shall order the violation corrected immediately. If the violation is not corrected, the commissioner may then order the premises or part of them immediately closed and to remain closed until the violation is corrected.

(b) Whenever a structure, by reason of age, neglect, want of repair, action of the elements, destruction, either partial or total by fire or other casualty or other cause, is so dilapidated, ruinous, decayed, filthy, unstable, or dangerous as to constitute a material menace or damage in any way to adjacent property, or to the public, and has so remained for a period of not less than one week, the commissioner may order such structure demolished and removed.

(c) Orders issued under this section shall be served by certified mail with return receipt requested or in the discretion of the commissioner, shall be served in the same manner as summonses are served under the Vermont Rules of Civil Procedure promulgated by the supreme court, to all persons who have a recorded interest in the property recorded in the place where land records for the property are recorded, including owners, tenants, mortgagees, attaching creditors, lien holders, and public utilities or water companies serving the premises.

§ 2734. Penalties

(a) A person who violates any provision of this subchapter or any order or rule issued pursuant thereto shall be fined not more than $10,000.00. The state's attorney of the county in which such violation occurs shall prosecute the violation and may commence a proceeding in the superior court to compel compliance with such order or rule, and such court may make orders and decrees therein by way of writ of injunction or otherwise.

(b) A person who fails to comply with a lawful order issued under authority of this subchapter in case of sudden emergency shall be fined not more than $20,000.00. A person who fails to comply with an order requiring notice shall be fined $200.00 for each day's neglect commencing with the effective date of such order or the date such order is finally determined if an appeal has been filed.

(c) The commissioner may, after notice and opportunity for hearing, assess an administrative penalty of not more than $1,000.00 for each violation of this subchapter or any rule adopted under this subchapter. Penalties assessed pursuant to this subsection shall be based on the severity of the violation. An election by the commissioner to proceed under this subsection shall not limit or restrict the commissioner's authority under subsection (a) of this section.

(d) Violation of any rule adopted under this subchapter shall be prima facie evidence of negligence in any civil action for damage or injury which is the result of the violation.

§ 2736. Municipal enforcement

(a) The legislative body of a municipality may appoint one or more trained and qualified officials and may establish procedures to enforce rules and standards adopted under subsection 2731(a) of this title. After considering the type of buildings within the municipality, if the commissioner determines that the training, qualifications and procedures are sufficient, he or she may assign responsibility to the municipality for enforcement of some or all of these rules and standards. The commissioner may also assign responsibility for enforcement of the rules of the access board adopted under section 2902 of this title. The commissioner shall provide continuing review, consultation, and assistance as may be necessary. The assignment of responsibility may be revoked by the commissioner after notice and an opportunity for hearing if the commissioner determines that the training, qualifications, or procedures are insufficient. The assignment of responsibility shall not affect the commissioner's authority under this subchapter.

(b) If a municipality assumes responsibility under subsection (a) of this section for performing any functions that would be subject to a fee established under subsection 2731(a) of this title, the municipality may establish and collect reasonable fees for its own use, and no fee shall be charged for the benefit of the state.

(c) Subject to rules adopted under section 2731 of this title, municipal officials appointed under this section may enter any premises in order to carry out the responsibilities of this section. The officials may order the repair, rehabilitation, closing, demolition, or removal of any premises to the same extent as the commissioner may under section 2732 of this title.

(d) Upon a determination by the commissioner that a municipality has established sufficient procedures for granting variances and exemptions, such variances and exemptions may be granted to the same extent authorized under subsection 2731(b) of this title.

(e) The results of all activities conducted by municipal officials under this section shall be reported to the commissioner periodically upon request.

(f) Nothing in this section shall be interpreted to decrease the authority of municipal officials under other laws, including laws concerning building codes and laws concerning housing codes

Current cooperative municipal inspection agreements include:

Barre *- Responsibility for the enforcement of the Code for existing one-two family dwellings.*
Bellows Falls *- Responsibility for the enforcement of the Code for all existing public buildings except federally certified health care facilities, high-rise buildings, state owned buildings, and the testing and reporting of fire protection systems by technically qualified people.*
Bennington *- Responsibility for the enforcement of the Code for all new & existing public buildings except federally certified health care facilities, high-rise buildings, state owned buildings, and the testing and reporting of fire protection systems by technically qualified people.*
Brattleboro *- Responsibility for the enforcement of the Code for all existing public buildings except federally certified health care facilities, high-rise buildings, state owned buildings, and the testing and reporting of fire protection systems by technically qualified people.*
Burlington *- Responsibility for the enforcement of the Code for all new and existing public buildings except federally certified health care facilities, state owned buildings, and the testing and reporting of fire protection systems by technically qualified people.*
Hartford *- Responsibility for the enforcement of the Code for all new and existing public buildings except federally certified health care facilities, state owned buildings, and the testing and reporting of fire protection systems by technically qualified people.*
Winooski *- Responsibility for the enforcement of the Code for existing public buildings with selected uses.*

§ 2737. Building permits

Each municipality shall provide to the commissioner upon request information regarding building permits issued by the municipality.

§ 2799. Definitions

As used in this subchapter:

(1) "Explosive material" includes "explosives," "explosive material," "blasting agents," and "detonators," as defined in section 841 of Title 18 of the United States Code, as amended at any time, and regulations promulgated thereunder.

(2) "Flammable material" means, in addition to its ordinary meaning, motion picture film.

(3) "Hazardous material" means any substance having such properties that it may spontaneously or acting under the influence of any thing contiguous or of any chemical or physical agency ignite or generate flammable or explosive vapors or gases to a dangerous extent.

(4) "Petroleum product" includes without limitation liquid petroleum gas, explosive flammable gases, and flammable fluids, compounds, or tablets, derived in whole or in part from petroleum.

§ 2800. Rules and standards

The commissioner may adopt rules and standards for explosion prevention, fire prevention, and public safety with respect to the safekeeping, storage, use, manufacturing, sale, handling, transportation, and other disposition of explosive materials, flammable materials, hazardous materials, petroleum, and petroleum products. The commissioner may prescribe the location, materials, and construction of buildings and other facilities to be used for these purposes.

§ 2801. Seizure of materials

Without warrant, the commissioner, a member of the state police, a sheriff, a deputy sheriff, a police officer, or a constable may seize materials held by a person in violation of rules adopted under this subchapter and hold the same subject to the order of the court taking jurisdiction of the offense.

§ 2802. Orders

After an inspection, the commissioner may issue an appropriate order to remove or abate a condition dangerous to persons or property involving explosive materials, flammable materials, or hazardous materials. This order shall be served on the owner or occupant of the premises on which the condition exists.

§ 2685. Record of fires

The fire marshal shall keep in his office a record of every fire occurring in this state which causes serious injury to any person or loss or damage to property in excess of $200.00. He shall record all the facts concerning these fires, including statistics as to their extent and the damage caused thereby, and whether the losses were covered by insurance and, if so, in what amount. The record shall be made daily from the reports made to him under the provisions of this chapter. All such records shall be public, except information and testimony taken where arson is suspected.

§ 2833. Reports to fire marshal

(a) The chief of a volunteer or paid fire department or, if there is no fire department, the first selectman of a town, shall within five days of the occurrence of a fire within his jurisdiction which causes serious injury to any person or loss or damage to property which exceeds $200.00, forward a report of the fire to the state fire marshal on forms to be furnished by him. If the reporting officer has reason to believe that a fire is of suspicious origin, he shall report that fact to the state fire marshal immediately. No fee shall be paid or allowed any officer for rendering the report required by this subsection.

(b) An officer referred to in subsection (a) of this section who wilfully neglects to comply with any of the requirements of this subchapter shall be fined not more than $100.00.

§ 2881. General provisions

(a) A person shall not install or maintain a boiler or pressure vessel which is unsafe or likely to be unsafe to other persons or property.

(b) A person shall not operate, cause to be operated, or permit to be operated any boiler or pressure vessel under his or her control or ownership, in a manner which causes or is likely to cause harm to other persons or property.

§ 2882. Rules

The commissioner may adopt rules pertaining to boilers and pressure vessels, and standards to be observed, necessary for the safety and protection of the public, employees and property. All standards adopted by the commissioner shall conform to the codes of the American Society of Mechanical Engineers and the National Board of Boiler and Pressure Vessel Inspectors. The commissioner may provide for operating certificates to be issued before a boiler or pressure vessel may be used.

§ 2883. Inspections by insurance companies

The commissioner has authority to obtain specific information from boiler insurance companies, on forms furnished by them, which shall first be approved by the commissioner. The commissioner may authorize qualified inspectors in the employ of insurance companies to conduct inspections under his or her control and under such rules as the commissioner may prescribe. In case the inspection is made by such an inspector, no fee shall be charged, except a process fee of $20.00 for issuance of an operating certificate.

§ 2884. Qualifications of inspectors

All boiler inspectors, employed by the state and insurance companies, shall have passed the examination required by the National Board of Boiler and Pressure Vessel Inspectors, and hold annual certification from such board.

§ 2885. Penalties

The commissioner may assess penalties pursuant to section 2734 of this title against a person who violates this subchapter or any rule adopted under this subchapter

Chapter 177 § 3131. Definitions

The term "fireworks" means any combustible or explosive composition, or any substance or combination of substances, or article prepared for the purpose of producing a visible or an audible effect by combustion, explosion, deflagration or detonation, including blank cartridges, toy pistols, toy cannons, toy canes, or toy guns in which explosives are used, balloons that are propelled by explosives, firecrackers, torpedoes, sky rockets, Roman candles, cherry bombs, or other fireworks of like construction and any fireworks containing any explosive or flammable compound, or any tablets or other device containing any explosive substance, except sparklers. The term "fireworks" does not include toy pistols, toy canes, toy guns, or other devices in which paper caps containing 0.25 grains or less of explosive compound are used, providing they are so constructed that the hand cannot come in contact with the cap when in place for use, and toy pistol paper caps that contain less than 0.2 grains of explosive mixture. The term "fireworks" does not include fixed ammunition for firearms, or primers for firearms. The term "sparkler" means a sparkling item that is in compliance with the United States Consumer Product Safety Commission regulations and is one of the following:

3132. Prohibitions; permits

(a) Except as provided in this section, it shall be unlawful for any person, firm, co-partnership, or corporation to do any of the following:

(1) Offer for sale, expose for sale, sell at retail or wholesale, or possess fireworks unless the person has been issued a permit by both the U.S. Bureau of Alcohol, Tobacco, and Firearms and the municipality in which the person offers for sale and stores the fireworks.

(2) Use, possess, or explode any fireworks unless the person has been issued a permit to display fireworks pursuant to subsection (c) of this section.

(3) Transport fireworks except in interstate commerce.

(4) Offer for sale or sell hand-held sparklers as described in subdivision 3131(1) of this title to a minor.

(5) Offer for sale or sell sparklers that are not in compliance with the United States Consumer Product Safety Commission regulations.

(b) The state fire marshal shall have power to adopt reasonable rules and regulations for granting permits for supervised public displays of fireworks by municipalities, fair associations, amusement parks, and other organizations or groups of individuals.

(c) Any display for which a permit is issued shall be handled by a competent operator to be approved by the chiefs of police and fire departments of the municipality in which the display is to be held and shall be of a character, and so located, discharged or fired as, in the opinion of the chief of the fire department, or in a municipality with no fire department, the selectboard, after proper inspection, shall not be hazardous to property or endanger any person or persons.

(d) Application for permits shall be made to the chief of the fire department, or in municipalities with no fire department, the selectboard, in writing, at least 15 days in advance of the date of the display. After the permit has been granted, sales, possessions, use and distribution of fireworks for the display shall be lawful for that purpose only. No permit granted under this section shall be transferable.

§ 3136. Construction

Being in the interest of public safety the provisions of this subchapter shall be liberally construed.

Annex II – Excerpts from the Architects and Professional Engineering Licensing and Registration Laws

§ 121. Definitions

(5) The "practice of architecture" means providing professional services such as consultation, investigation, evaluation, planning, designing (including structural design), or responsible supervision of construction in connection with any building or structure which has as its principal purpose human occupancy or habitation.

§ 124. Construction; exemptions

(a) This chapter shall not be construed to affect or prevent:

(1) the practice of engineering by a professional engineer licensed under the laws of this state;

(2) the preparation of working drawings, details and shop drawings by persons other than architects for use in connection with the execution of their work;

(3) employees of those lawfully practicing as architects under the provisions of this chapter from acting under the instruction, control, or supervision of their employers;

(4) supervision by builders or superintendents employed by such builders, of the construction or structural alteration of buildings or structures;

(5) design and construction, and the provision of services related thereto, of the following if the structure is:

(A) a detached single, two-family, three-family, or four-family dwelling, or a shed, storage building or garage incidental to that dwelling;

(B) a farm building, including barns, silos, sheds or housing for farm equipment and machinery, livestock, poultry or storage; or

(C) a pre-engineered building, or a building, plans for which have been stamped or sealed by a licensed professional in the appropriate field.

(b) The provisions of this section shall not be construed to permit any person not licensed as provided in this chapter to use the title architect, or any title, sign, card, or device to indicate that such person is an architect.

(c) This chapter shall not be construed to limit or restrict in any manner the right of a practitioner of another profession or occupation from carrying on in the usual manner any of the functions incidental to that profession or occupation.

§ 208. Seal

Each licensee shall obtain a seal of such design as the board shall authorize and direct. Plans and specifications prepared by, or under the direct supervision of, a licensed architect shall be stamped with the licensee's seal.

§ 1161. Definitions

(2) "Professional engineering services" means any service or creative work, the adequate performance of which requires engineering education, training and experience in the application of special knowledge of the mathematical, physical and engineering sciences. This includes consultation, investigation, evaluation, planning and design of engineering works and systems, planning the use of land and water and accomplishing engineering surveys. Such services or work may be either for public or private purposes, and may be performed in connection with any utilities, structures, buildings, machines, equipment, processes, work systems, projects, and equipment systems of a mechanical, electrical, hydraulic, pneumatic or thermal nature, insofar as they involve safeguarding life, health or property.

(6) "Professional engineer" means a person licensed under this chapter.

§ 1163. Exemptions

(a) Persons exempt. Section 1162 of this title does not prohibit acts constituting the practice of engineering performed as a necessary part of the duties of:

(1) An officer or employee of the federal government.

(2) An officer or a full-time employee of the state.

(3) An officer or full-time employee of a municipality.

(4) Certain classes of licensed potable water supply and wastewater system designers, as designated by rule of the secretary of the agency of natural resources, who design supplies or systems with a design flow of up to 1,350 gallons per day and who are licensed under chapter 64 of Title 10.

(5) An officer or employee of a corporation engaged in interstate commerce as defined in the act of Congress entitled "An Act to Regulate Commerce" approved February 4, 1887, as amended.

(6) An officer or employee of a corporation in interstate communications as defined in the act of Congress entitled "Communications Act of 1934" or of a telephone company under the supervision and regulation of the department of public service.

(7) An employee of a professional engineer.

(8) Students of engineering acting under the supervision of a professional engineer.

(b) Other professions. Section 1162 does not prohibit acts constituting the practice of any other legally recognized profession or occupation, including the activity of site technicians licensed by the agency of natural resources.

(b) Other professions. Section 1162 of this title does not prohibit acts constituting the practice of any other legally recognized profession or occupation.

(c) Purposes exempt. Section 1162 does not prohibit any person from performing acts constituting the practice of engineering for the purpose of:

(1) Designing or fabricating a manufactured product.

(2) Designing or constructing a building which is not a public building as defined in Title 18.

(3) Designing or constructing a building which contains only one, two or three dwelling units, or accessory outbuildings.

(4) Construction of public works by a municipality.

(5) Designing or constructing recreational trails and trail-related structures by a not-for-profit organization whose trails have been recognized by the agency of natural resources as part of the Vermont trails system; provided such organization purchases and maintains liability insurance in the amount required by law or under a contract with the state of Vermont, but in no event in an amount that is less than $100,000.00.

(e) Temporary practice. Section 1162 does not prohibit a person who has become a resident of this state within the preceding six months from performing acts constituting the practice of engineering, provided that:

(1) the person has filed an application for a license under this chapter; and

(2) the person is licensed or registered as a professional engineer in another state which, in the opinion of the board, has licensing standards substantially equivalent to those applicable under this chapter.

§ 1181a. Transient practice

A person who is not a resident of this state may obtain a transient practice permit to perform acts constituting the practice of engineering, provided that:

(1) the practice in this state does not exceed 30 days in any calendar year; and

(2) the person is licensed or registered as a professional engineer in another state which, in the opinion of the board, has regulatory standards substantially equivalent to those applicable under this chapter.

§ 1188. Seal

(a) Each licensee shall obtain a seal of a design authorized or approved by the board. The seal shall bear the licensee's name and the title "professional engineer."

(b) Plans, specifications, plats and reports issued by a licensee shall be stamped with his seal and shall also be signed by the licensee.

Annex III - Smoke & Carbon Monoxide Detection for Single-Family Owner Occupied Dwellings

§ 2881. Definitions

For the purpose of this chapter:

(1) "Single-family dwelling" means any building or structure in which a family, families or households reside that contains sleeping facilities and is not otherwise classified as a "public building" as defined in section 20 V.S.A. section 2730 or as a "condominium" or "multiple unit dwelling" as defined in section 20 V.S.A. section 2729(d).

(2) "Smoke detector" means a device that detects visible or invisible particles of combustion and sounds a warning alarm, is operated from a power supply, within the unit or wired to it from an outside source, and is approved or listed for the purpose by Underwriters Laboratory or by another nationally recognized independent testing laboratory.

(3) “Carbon monoxide detector” means a device with an assembly that incorporates a sensor control component and an alarm notification that detects elevations in carbon monoxide levels and sounds a warning alarm, is operated from a power supply within the unit or wired to it from an outside source, and is approved or listed for the purpose by Underwriters Laboratory or by another nationally recognized independent testing laboratory.

§ 2882. Installation

(a) A person who constructs a single-family dwelling shall install one or more smoke detectors, and one or more carbon monoxide detectors in the vicinity of any bedrooms in the dwelling in accordance with the manufacturer’s instructions. In a dwelling provided with electrical power, the detectors shall be powered by the electrical service in the building and by battery.

(b) A single-family dwelling transferred by sale or exchange shall contain one or more smoke detectors, and one or more carbon monoxide detectors powered by the electrical service in the building or by battery, or by a combination of both, and installed in accordance with the manufacturer's instructions.

(c) Nothing in this section shall require an owner or occupant of a single-family dwelling to maintain or use a smoke detector or a carbon monoxide detector after installation.

§ 2883. Requirements for transfer of dwelling

(a) The seller of a single-family dwelling, whether by sale or exchange, shall certify to the buyer at the closing of the transaction that the dwelling is provided with one or more smoke detectors and one or more carbon monoxide detectors in accordance with this chapter. This certification shall be signed and dated by the seller.

(b) If the buyer notifies the seller within ten days by certified mail from the date of conveyance of the dwelling that the dwelling lacks a smoke detector or a carbon monoxide detector or that either detector is not operable, the seller shall comply with this chapter within ten days after notification.

(c) Violation of this section or of the installation requirements of section 2882 shall not create a defect in title.

Annex IV - Information for Historic Buildings

Vermont has an unusually high proportion of older buildings. These buildings contribute substantially to the sense of community and place that makes Vermont unique. At the same time, these buildings may be particularly challenging to adaptively reuse. Owners of older and historic buildings should seek the assistance of experienced designers specializing in the preservation of these structures. Division for Historic Preservation and Division of Fire Safety staff will assist in using the features of this *Code* to preserve and enhance historic buildings. Clear and comprehensive information on the significant historic features needs to be provided to the Division to facilitate review.

There are a number of codes that are part of this *Cod*e specifically written for existing and historic buildings;

* NFPA 1, Fire Prevention Code, primarily addresses maintenance and the operation of buildings with performance guidelines for historic buildings.

* NFPA 73, Residential Electrical Code, addresses electrical code requirements in existing residential units.

* NFPA 101, Life Safety Code, principally addresses life safety issues and has specific chapters for existing buildings.

* NFPA 909, Protection of Cultural Resources including Museums, Libraries and places of worship, brings together the design and implementation of fire protection plans designed to protect both people and property.

*NFPA 914, Code for Fire Protection of Historic Structures, addresses the identification of existing conditions, planning and fire protection practices for historic buildings.

The regional offices of the Division of Fire Safety are staffed with safety professionals who have training and experience in developing solutions to meet both safety and historic preservation concerns. If a solution to a problem has not been developed after plan review or inspection, the owner or designated representative should contact the regional manager for assistance. With more experience and resources to draw on the regional manager often will develop a solution without requesting a formal variance.

For many buildings there are alternatives for certain code requirements that will provide an equivalent level of safety for the people using the building. To facilitate the review process for historic buildings, a fire safety plan should be developed. Guidance for that plan is found in Section 11.3.2 of NFPA 914 and Section 2.2 of NFPA 909. Additional flexibility is provided for historic buildings having the option to use the Alternative Approaches to Life Safety contained in NFPA 101A.

Fire Alarm and Detection Systems

Fire alarm and detection systems provide early warning of a fire allowing for safe evacuation of the building and a prompt response of fire suppression activities. There are numerous types, styles and designs of fire alarm and detection equipment that provide options and flexibility for sympathetic installation in historic buildings.
(See NFPA 914, Appendix F or NFPA 909, Appendix F for a general discussion of fire alarm systems and NFPA 101 Section 9.6)

Fire Extinguishing Systems

Automatic fire sprinkler systems and other types of automatic fire extinguishing systems provide early warning of a fire allowing for safe evacuation of the building and provide prompt suppression of the fire using a minimal amount of water. Each sprinkler head has to be heated to a certain temperature by a fire before water is released. Most fires are extinguished by the operation of just one or two sprinkler heads due to the prompt response by the sprinkler system. The amount of water applied to a fire is much less than what would need to be applied by a fire hose line.
(See NFPA 914, Appendix F or NFPA 909 Appendix F for a general discussion of fire extinguishing systems and NFPA 101 Section 9.7)

Automatic fire sprinkler systems have an excellent record of success in saving both people and property. Because of the excellent experience of automatic fire sprinkler systems the Codes have fewer requirements for buildings that have automatic fire sprinkler systems. For example, the Codes would drop or "trade off" certain requirements for historic buildings that have an automatic fire sprinkler system.

To promote the installation of fire sprinkler systems in existing buildings in designated downtown areas, a rebate of up to $2,000 of the construction permit fee is available to applicants where a complete fire sprinkler system is installed. The process for receiving the rebate includes providing documentation from the City or Town Clerk that the building is in a designated downtown area; completion of the fire sprinkler system in accordance with appropriate codes and final acceptance testing and approval of the fire sprinkler system. Vermont tax credits are also available for the installation of sprinkler systems and elevators in designated downtown areas, contact the Agency of Commerce & Community Development at 800-622-4553.

Maintenance and Testing of Fire Protection Systems

To help assure that fire protection systems will function properly when needed, all fire protection systems such as a fire alarm, sprinkler or kitchen hood exhaust systems are required to be tested periodically by a technically qualified person who is certified by the Division of Fire Safety. Upon completion of the test, the technically qualified person will affix an inspection sticker and notify the Division of Fire Safety of the results of the inspection.

Use of Archaic Building Materials

Building materials used within buildings are evaluated for "interior finish ratings" and "fire resistance ratings."

1) Interior finish ratings include evaluations for flame spread, fuel contribution and smoke development. Interior finish ratings are classified as A, B or C. Common archaic finish material such as plaster, tile flooring, wood flooring and metal ceilings will normally meet the standards for interior finish. Wood trim and incidental finish which is less than 10% of the aggregate wall and ceiling areas will also meet the standards for interior finish. Wood paneling which consists of more than 10% of the aggregate wall and ceiling areas will also meet the standards for interior finish in a number of historic buildings such as a bed and breakfast with 16 or fewer guests. However, in some buildings such as schools, the wood paneling would need to be treated with a fire retardant finish. The fire retardant finishes are available in both clear and solid color. The application of a fire retardant finish would not be required for wood paneling in a building provided with an automatic fire sprinkler system.

2) Fire resistance ratings evaluate building walls, ceilings or doors for the amount of time that it would resist the passage of fire. Construction assemblies can be evaluated by standard tests, rating guidelines published by nationally recognized authorities or by engineering analysis. Many common archaic construction assemblies have substantial resistance ratings while other assemblies may need to be enhanced to meet fire resistance requirements. Fire resistance requirements are commonly found in the code for separation walls that separate a more hazardous area from the rest of the building, such as a boiler room or stairway walls which protect the means of egress from a building. The requirements for construction or wall assemblies with fire resistance ratings in a building are reduced or totally eliminated for existing buildings with an automatic fire sprinkler system.

Field Guide for Historic Buildings

The Field Guide is designed to be used by those involved at all levels in the alteration process of historic and older buildings, including: trades persons, planners, architects, engineers, and property owners. The purpose of the Field Guide is to illustrate and describe successful examples of code compliance that reconcile safety considerations with preservation goals. In addition to explaining the code requirements and listing sources for further referencing, this guide also encourages and outlines the early and continued cooperation between those directly involved in the project with local code and preservation officials.

Annex V – Contact Information:

The Division of Fire Safety's four regional offices are located in:

Barre

Rutland

McFarland State Office Bldg.
5 Perry Street, Suite 200
Barre, VT 05641
802.479.4434
Fax: 802.479.4446

Fourth Floor
Asa Bloomer Build Suite 430
88 Merchants Row
Rutland, VT 05701
802.786.5867
Fax: 802.786.5872

Springfield

100 Mineral Street, Suite 307Springfield, VT 05156
802.885.8883
Fax: 802.885.8885

Williston

372 Hurricane Lane, Suite 102
Williston, VT 05495-7151
802.879.2300
Fax: 802.879.2312

The Vermont Fire Academy is located at:

317 Sanitorium Road
Pittsford, VT 05763
802.483.2755
Toll Free 800.615.3473
Fax: 802.483.2464

The Division of Fire Safety Main Office is located at:

1311 U. S. Route 302 - Berlin
Suite 600
Barre, Vermont 05641-2351

802.479.7561
Toll Free 800.640.2106
Fax: 802.479.7562

Codes and Standards Adopted and referenced under this ***Code*** are available at:

National Fire Protection Association
1 Batterymarch Park
Quincy Mass 02169-9101
1-800-344-3555
www.nfpa.org/

American Society of Heating Refrigeration
and Air Condition Engineers
1791 Tullie Circle N.E.
Atlanta, GA 30329
404-636-8400
www.ashrae.org/

American Society of Mechanical Engineers
22 Law Drive, Box 2900
Fairfield, NJ 07007
1-800-843-2763
www.asme.org/

American Society for Testing and Materials
100 Barr Harbor Drive
West Conshohocken PA 19428-2959
610-832-9585
www.astm.org/

American Welding Society, Inc.

550 N.W. Lejunne Road
P.O. Box 351040
Miami FL 33135
1-800-443-9353
www.aws.com

Compressed Gas Association, Inc.
4221 Walney Road, 5th Floor
Chantilly, VA 20151-2923
703-788-2700
www.cganet.com/default.html

International Code Council, Publications
4051 West Flossmoor Road
Country Club Hills
Illinois, 60478-5795
888-422-7233

National Board of Boiler & Pressure Vessel Inspectors
1055 Crupper Ave.
Columbus, Ohio 43229-1183
614-888-8320
nationalboard.org

Petroleum Equipment Institute

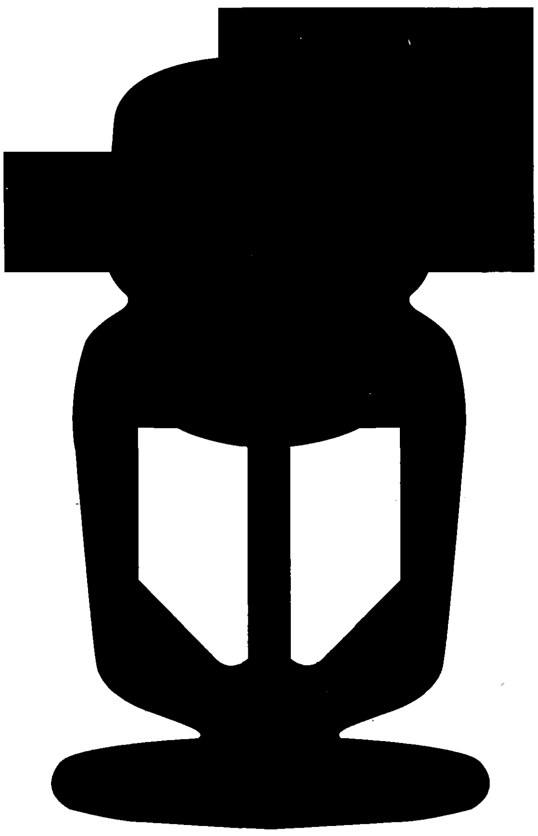
P.O. Box 2380
Tulsa OK 74101-2380
1-918-494-9696
www.pei.org

Underwriters Laboratories Inc.
333 Pfingsten Road
Northbrook IL 60062
847-272-8800
www.ul.com/

Annex VI -
Index by Topic & Occupancy

NFPA 13

Installation of Sprinkler Systems



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Installation of Sprinkler Systems 2002 NFPA 13

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In recognition of those who suffered
from the tragedies of September 11, 2001,
this document is dedicated to all who
have given their lives in an effort
to make this world a safer place.

NFPA 13

Standard for the

Installation of Sprinkler Systems

2002 Edition

This edition of NFPA 13, *Standard for the Installation of Sprinkler Systems,* was prepared by the Technical Committee on Hanging and Bracing of Water-Based Fire Protection Systems, the Technical Committee on Private Water Supply Piping Systems, the Technical Committee on Sprinkler System Discharge Criteria, and the Technical Committee on Sprinkler System Installation Criteria, released by the Technical Correlating Committee on Automatic Sprinkler Systems, and acted on by NFPA at its May Association Technical Meeting held May 19–23, 2002, in Minneapolis, MN. It was issued by the Standards Council on July 19, 2002, with an effective date of August 8, 2002, and supersedes all previous editions.

This edition of NFPA 13 was approved as an American National Standard on July 19, 2002.

Origin and Development of NFPA 13

NFPA 13 represents the first standard published under the auspices of the NFPA Committee on Automatic Sprinklers. Originally titled *Rules and Regulations of the National Board of Fire Underwriters for Sprinkler Equipments, Automatic and Open Systems,* the standard has been continuously updated to keep in step with change.

Full information about the NFPA actions on various changes will be found in the NFPA Proceedings. The dates of successive editions are as follows: 1896, 1899, 1902, 1905, 1907, 1908, 1912, 1913, 1915, 1916, 1917, 1919, 1920, 1921, 1922, 1923, 1924, 1925, 1926, 1927, 1928, 1929. In 1930, a separate standard was published on Class B systems. This was integrated into the 1931 edition. Further revisions were adopted in 1934, 1935, and 1936. A two-step revision was presented in the form of a progress report in 1939 and finally adopted in 1940. Further amendments were made in 1947, 1950, 1953, 1956, 1958, 1960, 1961, 1963, 1964, 1965, 1966, 1968, 1969, 1971, 1972, 1973, 1974, 1975, 1976, 1978, 1980, 1982, 1984, 1986, and 1989.

The 1991 edition incorporated an entire rewrite of the standard to make the overall format user friendly. Substantive changes were made to numerous terms, definitions, and descriptions, with additional refinements made in 1994.

The centennial (1996) edition included a significant rework of the requirements pertaining to the application, placement, location, spacing, and use of various types of sprinklers. Other changes provided information on extended coverage sprinklers and recognized the benefits of fast-response sprinkler technology.

The 1999 edition encompassed a major reorganization of NFPA's Sprinkler Project that included the establishment of a Technical Correlating Committee on Automatic Sprinkler Systems and four new sprinkler systems technical committees, the consolidation of NFPA's sprinkler system design and installation requirements, and the implementation of numerous technical changes.

The scope of NFPA 13 was expanded to address all sprinkler system applications. The 1999 edition contained information on the installation of underground pipe from NFPA 24 and sprinkler system discharge criteria for on-floor and rack storage of Class I, II, III, IV, and plastic commodities, rubber tires, baled cotton, and roll paper that were previously located in NFPA 231, 231C, 231D, 231E, and 231F. Additionally, sprinkler system information for specialized hazards from over 40 NFPA documents was either copied into NFPA 13 using NFPA's extract policy or specifically referenced. A new chapter was also added to address the structural aspects of exposed and buried system piping. A table of cross-references to previous editions and material that was located in other NFPA documents was included at the end of the 1999 edition.

More specific changes included a new sprinkler identification marking system and the designation of sprinkler sizes by nominal K-factors. New criteria for the use of steel pipe in underground applications was added, as well as a new provision to guard against microbiologically influenced corrosion. Obstruction rules for specific sprinkler types and rules for locating sprinklers in concealed spaces were revised. New limitations were placed on the sprinkler sizes in storage applications, and criteria for the K-25 sprinkler was added. Additionally, the requirements for protecting sprinklers against seismic events also underwent significant revision.

The 2002 edition of NFPA 13 has undergone style formatting and technical revisions. The style formatting was completed to comply with the NFPA *Manual of Style* and to reorganize many of the requirements in NFPA 13 into unique chapters. Editorially, NFPA 13 has eliminated all of the exceptions and reworded them as requirements where applicable, the mandatory references have been moved to Chapter 2, and all of the definitions are now located in Chapter 3. In reorganizing NFPA 13, several new chapters were created to consolidate requirements including the following: Chapter 10 contains all of the applicable requirements for underground piping including materials, installation, and acceptance testing; Chapter 11 contains design approaches including pipe schedule, density/area method, room design method, special design areas, residential sprinklers, exposure protection, and water curtains; Chapter 12 contains the design approaches for the protection of storage including idle pallets, miscellaneous storage, storage less than 12 ft, palletized, solid pile, bin box, and shelf storage, rack storage less than 25 ft, rack storage greater than 25 ft, rubber tire, baled cotton, rolled paper, and special storage designs; Chapter 13 contains all of the design and installation requirements from all of the various documents that have been extracted into NFPA 13.

The 2002 edition made specific technical changes to address several key issues. Three major areas of irregular ceiling have been addressed including skylights, stepped ceilings, and ceiling pockets. The design requirements for ESFR sprinklers have been expanded to allow the user to choose the storage height and then the building height for any allowable arrangement. Design requirements for the protection of storage on solid shelves have been added. Requirements for the installation of residential sprinklers were added that parallel the requirements for other types of sprinklers.

Prior editions of this document have been translated into languages other than English, including French and Spanish.

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Antonio C. M. Braga, FM Global, CA [I]
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J. William Sheppard, General Motors Corporation, MI [U]
John J. Walsh, Local 669 JATC, MD [SE]
(Member Emeritus)

Christian Dubay, NFPA Staff Liaison

Committee Scope: This Committee shall have overall responsibility for documents that pertain to the criteria for the design and installation of automatic, open, and foam-water sprinkler systems including the character and adequacy of water supplies and the selection of sprinklers, piping, valves, and all materials and accessories. This Committee does not cover the installation of tanks and towers, or the installation, maintenance, and use of central station, proprietary, auxiliary, and local signaling systems for watchmen, fire alarm, and supervisory service, or the design of fire department hose connections.

Technical Committee on Hanging and Bracing of Water-Based Fire Protection Systems (AUT-HBS)

Antonio C. M. Braga, *Chair*
FM Global, CA [I]

Samuel S. Dannaway, *Secretary*
S. S. Dannaway Associates, Inc., HI [SE]

James B. Biggins, Marsh Risk Consulting, IL [I]
Richard W. Bonds, Ductile Iron Pipe Research Association, AL [M]
Russell P. Fleming, National Fire Sprinkler Association, NY [M]
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Luke Hilton, LMG Property Engineering, FL [I]
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Terry Holst, Grinnell Fire Protection Systems Co., CA [M]
Rep. National Fire Sprinkler Association
Kraig Kirschner, AFCON, CA [M]
Rep. American Fire Sprinkler Association, Inc.
Philip D. LeGrone, Risk Management Solutions, Inc., TN [SE]
Wayne M. Martin, Wayne Martin & Associates Inc. (WMA), CA [SE]
Emil W. Misichko, Underwriters Laboratories Inc., IL [RT]
Donald C. Moeller, The RJA Group, Inc., CA [SE]
David S. Mowrer, HSB Professional Loss Control, TN [I]
Randy R. Nelson, VFS Fire Protection Services, CA [IM]
Rep. American Fire Sprinkler Association, Inc.
Janak B. Patel, Bechtel Savannah River Company, GA [U]
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Rep. United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the U.S. and Canada
James Tauby, Mason Industries, Inc., NY [M]
Jack Thacker, Allan Automatic Sprinkler Corporation of Southern California, CA [IM]
Rep. National Fire Sprinkler Association

Alternates

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(Alt. to L. Hilton)
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(Alt. to J. Thacker)
Russell G. Hoeltzel, Marsh Risk Consulting, CA [I]
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B. J. Lukes, Grinnell Fire Protection System Company Limited/Tyco, Canada [M]
(Alt. to T. Holst)
J. Scott Mitchell, American Fire Sprinkler Association, Inc., TX [M]
(Alt. to K. Kirschner)
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George Von Gnatensky, Tolco, Incorporated, CA [M]
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(Voting Alt. to IRI Rep.)

Christian Dubay, NFPA Staff Liaison

Committee Scope: This Committee shall have primary responsibility for those portions of NFPA 13 that pertain to the criteria for the use and installation of components and devices used for the support of water-based fire protection system piping including protection against seismic events.

Technical Committee on Private Water Supply Piping Systems (AUT-PRI)

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Richard W. Bonds, Ductile Iron Pipe Research Association, AL [M]
Phillip Brown, American Fire Sprinkler Association, Inc., TX [IM]
Richard Brown, Brown Sprinkler Corporation, KY [IM]
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Luke Hilton, LMG Property Engineering, FL [I]
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Gerald Kelliher, Westinghouse Savannah River Co., SC [U]
Marshall A. Klein, Marshall A. Klein and Associates, Inc., MD [SE]
John Lake, Marion County Fire/Rescue, FL [E]
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David S. Mowrer, HSB Professional Loss Control, TN [I]
Robert A. Panero, Pacific Gas and Electric Company, CA [U]
Rep. Edison Electric Institute
Sam (Sat) Salwan, Environmental Systems Design Inc., IL [SE]
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Rep. Illinois Fire Prevention Association
James W. Simms, The RJA Group, Inc., CA [SE]
Robert Spaulding, FM Global, MA [I]
Michael J. Stelzer, ABB Lummus Global, Inc., TX [SE]
Lynn K. Underwood, CNA Risk Management Property, IL [I]

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(Member Emeritus)
Geoffrey N. Perkins, Bassett Consulting Engineers, Australia

Christian Dubay, NFPA Staff Liaison

Committee Scope: This Committee shall have primary responsibility for documents on private piping systems supplying water for fire protection and for hydrants, hose houses, and valves. The Committee is also responsible for documents on fire flow testing and marking of hydrants.

Technical Committee on Sprinkler System Discharge Criteria (AUT-SSD)

Edward K. Budnick, *Chair*
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Robert B. Combs, Marsh USA, Inc., WA [I]
Thomas G. Deegan, The Viking Corporation, MI [M]
Richard H. Field, Royal & SunAlliance, NC [I]
Rep. American Insurance Services Group
Russell P. Fleming, National Fire Sprinkler Association, NY [M]
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James Golinveaux, Tyco Fire Products, RI [M]
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Joseph B. Hankins, Jr., FM Global, MA [I]
Roland J. Huggins, American Fire Sprinkler Association, Inc., TX [IM]
Larry Keeping, Vipond Fire Protection, Canada [IM]
Rep. Canadian Automatic Sprinkler Association
Andrew Kim, National Research Council of Canada, Canada [RT]
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Chris LaFleur, General Motors Corporation, MI [U]
Jerome P. Merkel, United Sprinkler, Inc., MN [IM]
Azarang Mirkhah, Las Vegas Fire Department, NV [E]
Richard Pehrson, Minnesota State Fire Marshal Division, MN [E]
Rep. International Fire Marshals Association
Chester W. Schirmer, Schirmer Engineering Corporation, NC [SE]
Todd E. Schumann, Industrial Risk Insurers, IL [I]
Peter A. Smith, International Paper Company, TN [U]
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David W. Stroup, U.S. National Institute of Standards and Technology, MD [RT]
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Rep. National Fire Sprinkler Association
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(Alt. to J. Golinveaux)
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(Alt. to W. J. Tomes)
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Nonvoting

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Christian Dubay, NFPA Staff Liaison

Committee Scope: This Committee shall have primary responsibility for those portions of NFPA 13 that pertain to the classification of various fire hazards and the determination of associated discharge criteria for sprinkler systems employing automatic and open sprinklers.

Technical Committee on Sprinkler System Installation Criteria (AUT-SSI)

Kenneth W. Linder, *Chair*
Industrial Risk Insurers, CT [I]

Kenneth E. Isman, *Secretary*
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Robert G. Caputo, Consolidated Fireprotection, Inc., CA [IM]
Rep. American Fire Sprinkler Association, Inc.
Robert E. Duke, Fire Control Incorporated, IL [IM]
Randall Eberly, U.S. Coast Guard Headquarters, DC [E]
Ralph Gerdes, Ralph Gerdes Consultants, LLC, IN [SE]
Rep. American Institute of Architects
Rick Glenn, Gage-Babcock & Associates, Inc. IL [SE]
Christopher M. Goddard, AstraZeneca, DE [U]
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Luke Hilton, LMG Property Engineering, FL [I]
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Larry Keeping, Vipond Fire Protection, Canada [IM]
Rep. Canadian Automatic Sprinkler Association
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Ausmus S. Marburger, Fire Protection Industries, Inc., PA [IM]
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Michael F. Meehan, Virginia Sprinkler Company, Inc., VA [IM]
Rep. American Fire Sprinkler Association, Inc.
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Joseph W. Noble, Clark County Fire Department, NV [E]
Rep. International Fire Marshals Association
Eric Packard, Local 669 JATC Education Fund, MD [L]
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Thomas H. Miller, Varley-Campbell & Associates, Inc./Village of Glen Ellyn, IL [SE]
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(Alt. to G. E. Laverick)
Mahendra "Kumar" H. Sheth, B.I.C. Design Company, MO [IM]
(Alt. to M. F. Meehan)
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Tom Vincent, Life Safety Systems, Canada [IM]
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Nonvoting

Barry M. Lee, Tyco International, Australia [M]

Christian Dubay, NFPA Staff Liaison

Committee Scope: This Committee shall have primary responsibility for those portions of NFPA 13 that pertain to the criteria for the use and installation of sprinkler system components (with the exception of those components used for support of piping), positioning of sprinklers, types of systems, plans and calculations, water supplies, and acceptance testing.

These lists represent the membership at the time the Committees were balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Contents

NFPA 13

Standard for the

Installation of Sprinkler Systems

2002 Edition

NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex E lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee.

Information on referenced publications can be found in Chapter 2 and Annex E.

Chapter 1 Administration

1.1* Scope. This standard shall provide the minimum requirements for the design and installation of automatic fire sprinkler systems and exposure protection sprinkler systems covered within this standard.

1.2* Purpose.

1.2.1 The purpose of this standard shall be to provide a reasonable degree of protection for life and property from fire through standardization of design, installation, and testing requirements for sprinkler systems, including private fire service mains, based on sound engineering principles, test data, and field experience.

1.2.2 Sprinkler systems and private fire service mains are specialized fire protection systems and shall require knowledgeable and experienced design and installation.

1.3 Application.

1.3.1 This standard shall apply to:

(1) Character and adequacy of water supplies
(2) Selection of sprinklers
(3) Fittings
(4) Piping
(5) Valves
(6) All materials and accessories, including the installation of private fire service mains

1.3.2 This standard shall also apply to "combined service mains" used to carry water for both fire service and other uses as well as mains for fire service use only.

1.4 Retroactivity Clause. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued. Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of this standard. Where specified, the provisions of this standard shall be retroactive. In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.5 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 New Technology.

1.6.1 Nothing in this standard shall be intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed by this standard is not lowered.

1.6.2 Materials or devices not specifically designated by this standard shall be utilized in complete accord with all conditions, requirements, and limitations of their listings.

1.7 Units and Symbols.

1.7.1 Units.

1.7.1.1 Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

1.7.1.2 Two units (liter and bar), outside of but recognized by SI, are commonly used in international fire protection.

1.7.1.3 These units are listed in Table 1.7.1.3 with conversion factors.

Table 1.7.1.3 SI Units and Conversion Factors

Name of Unit	Unit Symbol	Conversion Factor
liter	L	1 gal = 3.785 L
millimeter per minute	mm/min	1 gpm/ft^2 = 40.746 mm/min = 40.746 (L/min)/m^2
cubic decimeter	dm^3	1 gal = 3.785 dm^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10^5 Pa

Note: For additional conversions and information, see ASTM SI 10, *Standard for Use of the International System of Units (SI): The Modern Metric System.*

1.7.1.4 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated is to be regarded as the requirement.

1.7.2 Symbols. The standard abbreviations in Table 1.7.2 shall be used on the hydraulic calculation form discussed in Chapter 11.

Table 1.7.2 Hydraulic Symbols

Symbol or Abbreviation	Item
p	Pressure in psi
gpm	U.S. gallons per minute
q	Flow increment in gpm to be added at a specific location
Q	Summation of flow in gpm at a specific location
P_t	Total pressure in psi at a point in a pipe
P_f	Pressure loss due to friction between points indicated in location column
P_e	Pressure due to elevation difference between indicated points. This can be a plus value or a minus value. If minus, the (−) shall be used; if plus, no sign need be indicated.
P_v	Velocity pressure in psi at a point in a pipe
P_n	Normal pressure in psi at a point in a pipe
E	90-degree ell
EE	45-degree ell
Lt.E	Long-turn elbow
Cr	Cross
T	Tee-flow turned 90 degrees
GV	Gate valve
BV	Butterfly (wafer) check valve
Del V	Deluge valve
ALV	Alarm valve
DPV	Dry pipe valve
CV	Swing check valve
WCV	Butterfly (wafer) check valve
St	Strainer
psi	Pounds per square inch
v	Velocity of water in pipe in feet per second

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems,* 1999 edition.

NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* 2000 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2001 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 1999 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 1998 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2000 edition.

NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products,* 2002 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Film,* 2001 edition.

NFPA 42, *Code for the Storage of Pyroxylin Plastic,* 2002 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* 2000 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes,* 2002 edition.

NFPA 51A, *Standard for Acetylene Cylinder Charging Plants,* 2001 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 1999 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders,* 1998 edition.

NFPA 59, *Utility LP-Gas Plant Code,* 2001 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2001 edition.

NFPA 70, *National Electrical Code®,* 2002 edition.

NFPA 72®, National Fire Alarm Code®, 2002 edition.

NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment,* 1999 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment,* 1999 edition.

NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere,* 1999 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 2001 edition.

NFPA *101®, Life Safety Code®,* 2000 edition.

NFPA 170, *Standard for Fire Safety Symbols,* 2002 edition.

NFPA 214, *Standard on Water-Cooling Towers,* 2000 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* 1999 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 1998 edition.

NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves,* 2000 edition.

NFPA 409, *Standard on Aircraft Hangars,* 2001 edition.

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers,* 2000 edition.

NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials,* 2000 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 1998 edition.

2.3 Other Publications.

2.3.1 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME A17.1, *Safety Code for Elevators and Escalators,* 2000.

ASME B1.20.1, *Pipe Threads, General Purpose (Inch),* 2001.

ASME B16.1, *Cast Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250,* 1998.

ASME B16.3, *Malleable Iron Threaded Fittings, Classes 150 and 300,* 1998.

ASME B16.4, *Cast Iron Threaded Fittings, Classes 125 and 250,* 1998.

ASME B16.5, *Pipe Flanges and Flanged Fittings,* 1996.

ASME B16.9, *Factory-Made Wrought Steel Buttwelding Fittings,* 2001.

ASME B16.11, *Forged Steel Fittings, Socket-Welding and Threaded,* 1996.

ASME B16.18, *Cast Copper Alloy Solder Joint Pressure Fittings*, 1994.

ASME B16.22, *Wrought Copper and Copper Alloy Solder Joint Pressure Fittings*, 1995.

ASME B16.25, *Buttwelding Ends*, 1997.

ANSI/ASME B31.1, *Code for Power Piping*, 2001.

ANSI/ASME B36.10M, *Welded and Seamless Wrought Steel Pipe*, 2000.

2.3.2 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ANSI/ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*, 2001.

ASTM A 135, *Standard Specification for Electric-Resistance-Welded Steel Pipe*, 2001.

ASTM A 153, *Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware*, 2001.

ASTM A 234/A 234M, *Standard Specification for Piping Fittings of Wrought-Carbon Steel and Alloy Steel for Moderate and High Temperature Service*, 2001.

ASTM A 795, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*, 2000.

ASTM B 32, *Standard Specification for Solder Metal*, 2000.

ASTM B 75, *Standard Specification for Seamless Copper Tube*, 1999.

ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, 1999.

ASTM B 251, *Standard Specification for General Requirements for Wrought Seamless Copper and Copper-Alloy Tube*, 1997.

ASTM B 446, *Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNSN 06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNSN 06219) Rod and Bar*, 2000.

ASTM B 813, *Standard Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper-Alloy Tube*, 2000.

ASTM B 828, *Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings*, 2000.

ASTM D 3309, *Standard Specification for Polybutylene (PB) Plastic Hot- and Cold-Water Distribution Systems*, 1996.

ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2000.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1999.

ASTM F 437, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*, 1999.

ASTM F 438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40*, 2001.

ASTM F 439, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80*, 2001.

ASTM F 442, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR)*, 1999.

ASTM F 1121, *Standard Specification for International Shore Connections for Marine Fire Applications*, 1998.

ASTM SI 10, *Standard for Use of the International System of Units (SI): The Modern Metric System*, 1997.

2.3.3 AWS Publications. American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126.

AWS A5.8, *Specification for Filler Metals for Brazing and Braze Welding*, 1992.

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AWS D10.9, *Specification for Qualification of Welding Procedures and Welders for Piping and Tubing*, 1980.

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AWWA C105, *Polyethylene Encasement for Ductile Iron Pipe Systems*, 1999.

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AWWA C151, *Ductile Iron Pipe, Centrifugally Cast for Water*, 1996.

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AWWA C203, *Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape — Hot Applied*, 1997.

AWWA C205, *Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 in. (100 mm) and Larger — Shop Applied*, 2000.

AWWA C206, *Field Welding of Steel Water Pipe*, 1997.

AWWA C207, *Steel Pipe Flanges for Waterworks Service — Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm)*, 1994.

AWWA C208, *Dimensions for Fabricated Steel Water Pipe Fittings*, 1996.

AWWA C300, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*, 1997.

AWWA C301, *Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*, 1999.

AWWA C302, *Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids*, 1995.

AWWA C303, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids*, 1995.

AWWA C400, *Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in. (100 mm Through 400 mm), for Water and Other Liquids*, 1998.

AWWA C401, *Standard Practice for the Selection of Asbestos-Cement Water Pipe, 4 in. Through 16 in. (100 mm Through 400 mm)*, 1998.

AWWA C600, *Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances*, 1999.

AWWA C602, *Cement-Mortar Lining of Water Pipe Lines 4 in. (100 mm) and Larger — in Place*, 2000.

AWWA C603, *Standard for the Installation of Asbestos-Cement Water Pipe*, 1996.

AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in. (100 mm Through 300 mm), for Water and Other Liquids*, 1997.

AWWA M11, *A Guide for Steel Pipe Design and Installation*, 3rd edition, 1989.

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IEEE 45, *Recommended Practice for Electric Installations on Shipboard*, 1998.

2.3.6 UL Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 300, *Standard for Safety Fire Testing of Fire Extinguishing Systems for Protection of Restaurant Cooking Areas*, 1998.

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Title 46, *Code of Federal Regulations*, Subchapter F, "Marine Engineering."

Title 46, *Code of Federal Regulations*, Subchapter J, "Electrical Engineering."

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.3* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.4 Shall. Indicates a mandatory requirement.

3.2.5 Should. Indicates a recommendation or that which is advised but not required.

3.2.6 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix or annex, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Automatic Sprinkler. A fire suppression or control device that operates automatically when its heat-activated element is heated to its thermal rating or above, allowing water to discharge over a specified area.

3.3.2 Automotive Components on Portable Racks. Automotive components on portable racks are defined as the following: instrument panels, windshields, metal and plastic gasoline tanks, heater housings, door panels, interior trim, bumper facia, wiring harnesses, sheet metal, body components, engines, driveline components, steering mechanisms, auxiliary motors, and lighting — all with or without expanded plastic donnage. This definition does not include the storage of air bags, tires, and seats on portable racks.

3.3.3* Bathroom. Within a dwelling unit, any room or compartment containing a lavatory dedicated to personal hygiene, or a water closet, or bathing capability such as a shower or tub, or any combination of facilities thereof.

3.3.4 Ceiling Height. The distance between the floor and the underside of the ceiling above (or roof deck) within the area.

3.3.5 Ceiling Types.

3.3.5.1 Flat Ceiling. A continuous ceiling in a single plane.

3.3.5.2 Horizontal Ceiling. A ceiling with a slope not exceeding 2 in 12.

3.3.5.3 Sloped Ceiling. A ceiling with a slope exceeding 2 in 12.

3.3.5.4 Smooth Ceiling. A continuous ceiling free from significant irregularities, lumps, or indentations.

3.3.6 Compartment. A space completely enclosed by walls and a ceiling. The compartment enclosure is permitted to have openings to an adjoining space if the openings have a minimum lintel depth of 8 in. (203 mm) from the ceiling.

3.3.7 Drop-Out Ceiling. A suspended ceiling system, which is installed below the sprinklers, with listed translucent or opaque panels that are heat sensitive and fall from their setting when exposed to heat.

3.3.8 Dwelling Unit. One or more rooms arranged for the use of one or more individuals living together, as in a single housekeeping unit normally having cooking, living, sanitary, and sleeping facilities. For purposes of this standard, dwelling unit includes hotel rooms, dormitory rooms, apartments, condominiums, sleeping rooms in nursing homes, and similar living units.

3.3.9 Fire Control. Limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures to avoid structural damage.

3.3.10 Fire Suppression. Sharply reducing the heat release rate of a fire and preventing its regrowth by means of direct and sufficient application of water through the fire plume to the burning fuel surface.

3.3.11 High-Challenge Fire Hazard. A fire hazard typical of that produced by fires in combustible high-piled storage.

3.3.12 High-Piled Storage. Solid-piled, palletized, rack storage, bin box, and shelf storage in excess of 12 ft (3.7 m) in height.

3.3.13 Hydraulically Designed System. A calculated sprinkler system in which pipe sizes are selected on a pressure loss basis to provide a prescribed water density, in gallons per minute per square foot (mm/min), or a prescribed minimum discharge pressure or flow per sprinkler, distributed with a reasonable degree of uniformity over a specified area.

3.3.14 Limited-Combustible Material. A building construction material that does not comply with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu per lb (8141 kJ/kg) *(see NFPA 359, Standard Test Method for Potential Heat of Building Materials)*, and that complies with either of the following, (a) or (b). Materials subject to increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric condition shall be considered combustible. (a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of ⅛ in. (3.2 mm) that has a flame spread rating not greater than 50. (b) Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion.

3.3.15* Miscellaneous Storage. Storage that does not exceed 12 ft (3.66 m) in height and is incidental to another occupancy use group. Such storage shall not constitute more than 10 percent of the building area or 4000 ft^2 (372 m^2) of the sprinklered area, whichever is greater. Such storage shall not exceed 1000 ft^2 (93 m^2) in one pile or area, and each such pile or area shall be separated from other storage areas by at least 25 ft (7.62 m).

3.3.16 Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

3.3.17 Pipe Schedule System. A sprinkler system in which the pipe sizing is selected from a schedule that is determined by the occupancy classification and in which a given number of sprinklers are allowed to be supplied from specific sizes of pipe.

3.3.18* Reinforced Plastic Pallet. A plastic pallet incorporating a secondary reinforcing material (such as steel or fiberglass) within the pallet.

3.3.19 Shop-Welded. As used in this standard, *shop* in the term *shop-welded* means either (1) a sprinkler contractor's or fabricator's premise or (2) an area specifically designed or authorized for welding, such as a detached outside location, maintenance shop, or other area (either temporary or permanent) of noncombustible or fire-resistive construction free of combustible and flammable contents and suitably segregated from adjacent areas.

3.3.20 Small Rooms. A room of light hazard occupancy classification having unobstructed construction and floor areas not exceeding 800 ft^2 (74.3 m^2) that are enclosed by walls and a ceiling. Openings to the adjoining space are permitted if the minimum lintel depth is 8 in. (203 mm) from the ceiling.

3.3.21* Sprinkler System. For fire protection purposes, an integrated system of underground and overhead piping designed in accordance with fire protection engineering standards. The installation includes one or more automatic water supplies. The portion of the sprinkler system aboveground is a network of specially sized or hydraulically designed piping installed in a building, structure, or area, generally overhead, and to which sprinklers are attached in a systematic pattern. The valve controlling each system riser is located in the system riser or its supply piping. Each sprinkler system riser includes a device for actuating an alarm when the system is in operation. The system is usually activated by heat from a fire and discharges water over the fire area.

3.3.22 System Working Pressure. The maximum anticipated static (nonflowing) or flowing pressure applied to sprinkler system components exclusive of surge pressures.

3.3.23 Thermal Barrier. A material that will limit the average temperature rise of the unexposed surface to not more than 250°F (121°C) after 15 minutes of fire exposure, which complies with the standard time-temperature curve of NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*.

3.4 Sprinkler System Type Definitions.

3.4.1 Antifreeze Sprinkler System. A wet pipe sprinkler system employing automatic sprinklers that are attached to a piping system that contains an antifreeze solution and that are connected to a water supply. The antifreeze solution is discharged, followed by water, immediately upon operation of sprinklers opened by heat from a fire.

3.4.2 Circulating Closed-Loop Sprinkler System. A wet pipe sprinkler system having non–fire protection connections to automatic sprinkler systems in a closed-loop piping arrangement for the purpose of utilizing sprinkler piping to conduct water for heating or cooling, where water is not removed or used from the system but only circulated through the piping system.

3.4.3 Combined Dry Pipe-Preaction Sprinkler System. A sprinkler system employing automatic sprinklers attached to a piping system containing air under pressure with a supplemental detection system installed in the same areas as the sprinklers. Operation of the detection system actuates tripping devices that open dry pipe valves simultaneously and without loss of air pressure in the system. Operation of the detection system also opens listed air exhaust valves at the end of the feed main, which usually precedes the opening of sprinklers. The detection system also serves as an automatic fire alarm system.

3.4.4 Deluge Sprinkler System. A sprinkler system employing open sprinklers that are attached to a piping system that is

connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

3.4.5 Dry Pipe Sprinkler System. A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers.

3.4.6* Gridded Sprinkler System. A sprinkler system in which parallel cross mains are connected by multiple branch lines. An operating sprinkler will receive water from both ends of its branch line while other branch lines help transfer water between cross mains.

3.4.7* Looped Sprinkler System. A sprinkler system in which multiple cross mains are tied together so as to provide more than one path for water to flow to an operating sprinkler and branch lines are not tied together.

3.4.8* Preaction Sprinkler System. A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure, with a supplemental detection system installed in the same areas as the sprinklers.

3.4.9 Wet Pipe Sprinkler System. A sprinkler system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire.

3.5* System Component Definitions.

3.5.1 Branch Lines. The pipes in which the sprinklers are placed, either directly or through risers.

3.5.2 Cross Mains. The pipes supplying the branch lines, either directly or through risers.

3.5.3 Feed Mains. The pipes supplying cross mains, either directly or through risers.

3.5.4 Flexible Listed Pipe Coupling. A listed coupling or fitting that allows axial displacement, rotation, and at least 1 degree of angular movement of the pipe without inducing harm on the pipe. For pipe diameters of 8 in. (203.2 mm) and larger, the angular movement shall be permitted to be less than 1 degree but not less than 0.5 degree.

3.5.5 Risers. The vertical supply pipes in a sprinkler system.

3.5.6 Sprig-up. A line that rises vertically and supplies a single sprinkler.

3.5.7 Supervisory Device. A device arranged to supervise the operative condition of automatic sprinkler systems.

3.5.8 System Riser. The aboveground horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe) and a waterflow alarm device.

3.6 Sprinkler Definitions.

3.6.1* General. The following are characteristics of a sprinkler that define its ability to control or extinguish a fire. (a) Thermal sensitivity. A measure of the rapidity with which the thermal element operates as installed in a specific sprinkler or sprinkler assembly. One measure of thermal sensitivity is the response time index (RTI) as measured under standardized test conditions. (1) Sprinklers defined as fast response have a thermal element with an RTI of 50 (meters-seconds)$^{1/2}$ or less. (2) Sprinklers defined as standard response have a thermal element with an RTI of 80 (meters-seconds)$^{1/2}$ or more. (b) Temperature rating. (c) Orifice size *(see Chapter 6)*. (d) Installation orientation *(see 3.6.3)*. (e) Water distribution characteristics (i.e., application rate, wall wetting). (f) Special service conditions *(see 3.6.4)*.

3.6.2 Sprinkler Types. The following sprinklers are defined according to design and performance characteristics.

3.6.2.1* Early Suppression Fast-Response (ESFR) Sprinkler. A type of fast-response sprinkler that meets the criteria of 3.6.1(a)(1) and is listed for its capability to provide fire suppression of specific high-challenge fire hazards.

3.6.2.2 Extended Coverage Sprinkler. A type of spray sprinkler with maximum coverage areas as specified in Sections 8.8 and 8.9 of this standard.

3.6.2.3 Large Drop Sprinkler. A type of specific application control mode sprinkler that is capable of producing characteristic large water droplets and that is listed for its capability to provide fire control of specific high-challenge fire hazards.

3.6.2.4 Nozzles. A device for use in applications requiring special water discharge patterns, directional spray, or other unusual discharge characteristics.

3.6.2.5 Old-Style/Conventional Sprinkler. A sprinkler that directs from 40 percent to 60 percent of the total water initially in a downward direction and that is designed to be installed with the deflector either upright or pendent.

3.6.2.6 Open Sprinkler. A sprinkler that does not have actuators or heat-responsive elements.

3.6.2.7* Quick-Response Early Suppression (QRES) Sprinkler. A type of quick-response sprinkler that meets the criteria of 3.6.1(a)(1) and is listed for its capability to provide fire suppression of specific fire hazards.

3.6.2.8 Quick-Response Extended Coverage Sprinkler. A type of quick-response sprinkler that meets the criteria of 3.6.1(a)(1) and complies with the extended protection areas defined in Chapter 8.

3.6.2.9 Quick-Response (QR) Sprinkler. A type of spray sprinkler that meets the criteria of 3.6.1(a)(1) and is listed as a quick-response sprinkler for its intended use.

3.6.2.10 Residential Sprinkler. A type of fast-response sprinkler that meets the criteria of 3.6.1(a)(1) that has been specifically investigated for its ability to enhance survivability in the room of fire origin and is listed for use in the protection of dwelling units.

3.6.2.11 Special Sprinkler. A sprinkler that has been tested and listed as prescribed in 8.4.9.

3.6.2.12* Specific Application Control Mode Sprinkler (for Storage Use). A type of spray sprinkler listed at a minimum operating pressure with a specific number of operating sprinklers for a given protection scheme.

3.6.2.13 Spray Sprinkler. A type of sprinkler listed for its capability to provide fire control for a wide range of fire hazards.

3.6.2.14 Standard Spray Sprinkler. A spray sprinkler with maximum coverage areas as specified in Sections 8.6 and 8.7 of this standard.

3.6.3 Installation Orientation. The following sprinklers are defined according to orientation.

3.6.3.1 Concealed Sprinkler. A recessed sprinkler with cover plates.

3.6.3.2 Flush Sprinkler. A sprinkler in which all or part of the body, including the shank thread, is mounted above the lower plane of the ceiling.

3.6.3.3 Pendent Sprinkler. A sprinkler designed to be installed in such a way that the water stream is directed downward against the deflector.

3.6.3.4 Recessed Sprinkler. A sprinkler in which all or part of the body, other than the shank thread, is mounted within a recessed housing.

3.6.3.5 Sidewall Sprinkler. A sprinkler having special deflectors that are designed to discharge most of the water away from the nearby wall in a pattern resembling one-quarter of a sphere, with a small portion of the discharge directed at the wall behind the sprinkler.

3.6.3.6 Upright Sprinkler. A sprinkler designed to be installed in such a way that the water spray is directed upwards against the deflector.

3.6.4 Special Service Conditions. The following sprinklers are defined according to special application or environment.

3.6.4.1 Corrosion-Resistant Sprinkler. A sprinkler fabricated with corrosion-resistant material, or with special coatings or platings, to be used in an atmosphere that would normally corrode sprinklers.

3.6.4.2* Dry Sprinkler. A sprinkler secured in an extension nipple that has a seal at the inlet end to prevent water from entering the nipple until the sprinkler operates.

3.6.4.3 Intermediate Level Sprinkler/Rack Storage Sprinkler. A sprinkler equipped with integral shields to protect its operating elements from the discharge of sprinklers installed at higher elevations.

3.6.4.4 Ornamental/Decorative Sprinkler. A sprinkler that has been painted or plated by the manufacturer.

3.7 Construction Definitions.

3.7.1* Obstructed Construction. Panel construction and other construction where beams, trusses, or other members impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire.

3.7.2* Unobstructed Construction. Construction where beams, trusses, or other members do not impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire. Unobstructed construction has horizontal structural members that are not solid, where the openings are at least 70 percent of the cross-section area and the depth of the member does not exceed the least dimension of the openings, or all construction types where the spacing of structural members exceeds 7½ ft (2.3 m) on center.

3.8 Private Water Supply Piping Definitions.

3.8.1* Private Fire Service Main. Private fire service main, as used in this standard, is that pipe and its appurtenances on private property (1) between a source of water and the base of the system riser for water-based fire protection systems, (2) between a source of water and inlets to foam-making systems, (3) between a source of water and the base elbow of private hydrants or monitor nozzles, and (4) used as fire pump suction and discharge piping, (5) beginning at the inlet side of the check valve on a gravity or pressure tank.

3.9 Palletized, Solid Pile, Bin Box, and Shelf Storage Definitions.

3.9.1 Array.

3.9.1.1 Closed Array. A storage arrangement where air movement through the pile is restricted because of 6-in. (152-mm) or less vertical flues.

3.9.1.2* Open Array. A storage arrangement where air movement through the pile is enhanced because of vertical flues larger than 6 in. (152 mm).

3.9.2* Available Height for Storage. The maximum height at which commodities can be stored above the floor and still maintain adequate clearance from structural members and the required clearance below sprinklers.

3.9.3 Bin Box Storage. Storage in five-sided wood, metal, or cardboard boxes with open face on the aisles. Boxes are self-supporting or supported by a structure so designed that little or no horizontal or vertical space exists around boxes.

3.9.4 Clearance. The distance from the top of storage to the ceiling sprinkler deflectors.

3.9.5 Commodity. Combinations of products, packing material, and container upon which the commodity classification is based.

3.9.6* Compartmented. The rigid separation of the products in a container by dividers that form a stable unit under fire conditions.

3.9.7* Container (Shipping, Master, or Outer Container). A receptacle strong enough, by reason of material, design, and construction, to be shipped safely without further packaging.

3.9.8 Encapsulation. A method of packaging consisting of a plastic sheet completely enclosing the sides and top of a pallet load containing a combustible commodity or a combustible package or a group of combustible commodities or combustible packages. Combustible commodities individually wrapped in plastic sheeting and stored exposed in a pallet load also are to be considered encapsulated. Totally noncombustible commodities on wood pallets enclosed only by a plastic sheet as described are not covered under this definition. Banding (i.e., stretch-wrapping around the sides only of a pallet load) is not considered to be encapsulation. Where there are holes or voids in the plastic or waterproof cover on the top of the carton that exceed more than half of the area of the cover, the term *encapsulated* does not apply. The term *encapsulated* does not apply to plastic-enclosed products or packages inside a large, nonplastic, enclosed container.

3.9.9 Expanded (Foamed or Cellular) Plastics. Those plastics, the density of which is reduced by the presence of numerous small cavities (cells), interconnecting or not, dispersed throughout their mass.

3.9.10 Exposed Group A Plastic Commodities. Those plastics not in packaging or coverings that absorb water or otherwise appreciably retard the burning hazard of the commodity. (Paper wrapped or encapsulated, or both, should be considered exposed.)

3.9.11 Free-Flowing Plastic Materials. Those plastics that fall out of their containers during a fire, fill flue spaces, and create a smothering effect on the fire. Examples include powder, pellets, flakes, or random-packed small objects [e.g., razor blade dispensers, 1-oz to 2-oz (28-g to 57-g) bottles].

3.9.12 Packaging. A commodity wrapping, cushioning, or container.

3.9.13 Palletized Storage. Storage of commodities on pallets or other storage aids that form horizontal spaces between tiers of storage.

3.9.14* Pile Stability, Stable Piles. Those arrays where collapse, spillage of content, or leaning of stacks across flue spaces is not likely to occur soon after initial fire development.

3.9.15* Pile Stability, Unstable Piles. Those arrays where collapse, spillage of contents, or leaning of stacks across flue spaces occurs soon after initial fire development.

3.9.16 Roof Height. The distance between the floor and the underside of the roof deck within the storage area.

3.9.17 Shelf Storage. Storage on structures less than 30 in. (76.2 cm) deep with shelves usually 2 ft (0.6 m) apart vertically and separated by approximately 30-in. (76.2-cm) aisles.

3.9.18 Solid Unit Load of a Nonexpanded Plastic (Either Cartoned or Exposed). A load that does not have voids (air) within the load and that burns only on the exterior of the load; water from sprinklers might reach most surfaces available to burn.

3.9.19 Storage Aids. Commodity storage devices, such as pallets, dunnage, separators, and skids.

3.9.20 Unit Load. A pallet load or module held together in some manner and normally transported by material handling equipment.

3.10 Rack Storage Definitions.

3.10.1* Aisle Width. The horizontal dimension between the face of the loads in racks under consideration. *(See Figure A.3.10.1.)*

3.10.2 Bulkhead. A vertical barrier across the rack.

3.10.3 Cartoned. A method of storage consisting of corrugated cardboard or paperboard containers fully enclosing the commodity.

3.10.4* Conventional Pallets. A material-handling aid designed to support a unit load with openings to provide access for material-handling devices. *(See Figure A.3.10.4.)*

3.10.5 Face Sprinklers. Standard sprinklers that are located in transverse flue spaces along the aisle or in the rack, are within 18 in. (0.46 m) of the aisle face of storage, and are used to oppose vertical development of fire on the external face of storage.

3.10.6 Horizontal Barrier. A solid barrier in the horizontal position covering the entire rack, including all flue spaces at certain height increments, to prevent vertical fire spread.

3.10.7* Longitudinal Flue Space. The space between rows of storage perpendicular to the direction of loading. *(See Figure A.3.10.7.)*

3.10.8* Rack. Any combination of vertical, horizontal, and diagonal members that supports stored materials. Some rack structures use solid shelves. Racks can be fixed, portable, or movable. Loading can be either manual — using lift trucks, stacker cranes, or hand placement — or automatic — using machine-controlled storage and retrieval systems.

3.10.8.1 Double-Row Racks. Two single-row racks placed back-to-back having a combined width up to 12 ft (3.7 m), with aisles at least 3.5 ft (1.1 m) on each side.

3.10.8.2 Movable Racks. Racks on fixed rails or guides. They can be moved back and forth only in a horizontal, two-dimensional plane. A moving aisle is created as abutting racks are either loaded or unloaded, then moved across the aisle to abut other racks.

3.10.8.3 Multiple-Row Racks. Racks greater than 12 ft (3.7 m) wide or single- or double-row racks separated by aisles less than 3.5 ft (1.1 m) wide having an overall width greater than 12 ft (3.7 m).

3.10.8.4 Portable Racks. Racks that are not fixed in place. They can be arranged in any number of configurations.

3.10.8.5 Single-Row Racks. Racks that have no longitudinal flue space and that have a width up to 6 ft (1.8 m) with aisles at least 3.5 ft (1.1 m) from other storage.

3.10.9 Slave Pallet. A special pallet captive to a material-handling system. *(See Figure A.3.10.4.)*

3.10.10 Solid Shelving. Solid shelving is fixed in place, slatted, wire mesh or other type of shelves located within racks. The area of a solid shelf is defined by perimeter aisle or flue space on all four sides. Solid shelves having an area equal to or less than 20 ft^2 shall be defined as open racks. Shelves of wire mesh, slates, or other materials more than 50 percent open and where the flue spaces are maintained shall be defined as open racks.

3.10.11 Transverse Flue Space. The space between rows of storage parallel to the direction of loading. *(See Figure A.3.10.7.)*

3.11 Rubber Tire Storage Definitions.

3.11.1 Banded Tires. A storage method in which a number of tires are strapped together.

3.11.2 Horizontal Channel. Any uninterrupted space in excess of 5 ft (1.5 m) in length between horizontal layers of stored tires. Such channels can be formed by pallets, shelving, racks, or other storage arrangements.

3.11.3 Laced Tire Storage. Tires stored where the sides of the tires overlap, creating a woven or laced appearance. *[See Figure A.3.11.9(g).]*

3.11.4* Miscellaneous Tire Storage. The storage of rubber tires that is incidental to the main use of the building. Storage areas shall not exceed 2000 ft^2 (186 m^2). On-tread storage piles, regardless of storage method, shall not exceed 25 ft (7.6 m) in the direction of the wheel holes. Acceptable storage arrangements include (a) on-floor, on-side storage up to 12 ft (3.7 m) high; (b) on-floor, on-tread storage up to 5 ft (1.5 m) high; (c) double-row or multirow fixed or portable rack storage on-side or on-tread up to 5 ft (1.5 m) high; (d) single row fixed or portable rack storage on-side or on-tread up to 12 ft

(3.7 m) high; and (e) laced tires in racks up to 5 ft (1.5 m) in height.

3.11.5 On-Side Tire Storage. Tires stored horizontally or flat.

3.11.6 On-Tread Tire Storage. Tires stored vertically or on their treads.

3.11.7 Palletized Tire Storage. Storage on portable racks of various types utilizing a conventional pallet as a base.

3.11.8 Pyramid Tire Storage. On-floor storage in which tires are formed into a pyramid to provide pile stability.

3.11.9* Rubber Tire Rack Illustrations. See Figure A.3.11.9(a) through Figure A.3.11.9(g).

3.11.10 Rubber Tires. Pneumatic tires for passenger automobiles, aircraft, light and heavy trucks, trailers, farm equipment, construction equipment (off-the-road), and buses.

3.12 Baled Cotton Definitions.

3.12.1* Baled Cotton. A natural seed fiber wrapped and secured in industry-accepted materials, usually consisting of burlap, woven polypropylene or sheet polyethylene, and secured with steel, synthetic or wire bands, or wire; can also include linters (lint removed from the cottonseed) and motes (residual materials from the ginning process). *(See Table A.3.12.1.)*

3.12.2 Block Cotton Storage. The number of bales closely stacked in cubical form and enclosed by aisles or building sides, or both.

3.12.3 Cold Cotton. Baled cotton five or more days old after the ginning process.

3.12.4 Fire-Packed. A bale within which a fire has been packed as a result of a process, with ginning being the most frequent cause.

3.12.5 Naked Cotton Bale. A bale secured with wire or steel straps without wrapping.

3.13 Roll Paper Definitions.

3.13.1 Array (Paper).

3.13.1.1 Closed Array (Paper). A vertical storage arrangement in which the distances between columns in both directions are short [not more than 2 in. (50 mm) in one direction and 1 in. (25 mm) in the other].

3.13.1.2 Open Array (Paper). A vertical storage arrangement in which the distance between columns in both directions is lengthy (all vertical arrays other than closed or standard).

3.13.1.3* Standard Array (Paper). A vertical storage arrangement in which the distance between columns in one direction is short [1 in. (25 mm) or less] and is in excess of 2 in. (50 mm) in the other direction.

3.13.2 Banded Roll Paper Storage. Rolls provided with a circumferential steel strap [⅜ in. (9.5 mm) or wider] at each end of the roll.

3.13.3 Column. A single vertical stack of rolls.

3.13.4 Core. The central tube around which paper is wound to form a roll.

3.13.5 Paper (General Term). The term for all kinds of felted sheets made from natural fibrous materials, usually vegetable but sometimes mineral or animal, and formed on a fine wire screen from water suspension.

3.13.6 Roll Paper Storage.

3.13.6.1 Horizontal Roll Paper Storage. Rolls stored with the cores in the horizontal plane (on-side storage).

3.13.6.2 Vertical Roll Paper Storage. Rolls stored with the cores in the vertical plane (on-end storage).

3.13.6.3* Wrapped Roll Paper Storage. Rolls provided with a complete heavy kraft covering around both sides and ends.

3.13.7* Roll Paper Storage Height. The maximum vertical distance above the floor at which roll paper is normally stored.

3.14 Marine Definitions. These definitions apply to Chapter 17 only.

3.14.1 A-Class Boundary. A boundary designed to resist the passage of smoke and flame for 1 hour when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials.*

3.14.2 B-Class Boundary. A boundary designed to resist the passage of flame for ½ hour when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials.*

3.14.3 Central Safety Station A continuously manned control station from which all of the fire control equipment is monitored. If this station is not the bridge, direct communication with the bridge shall be provided by means other than the ship's service telephone.

3.14.4* Heat-Sensitive Material. A material whose melting point is below 1700°F (926.7°C).

3.14.5 Heel. The inclination of a ship to one side.

3.14.6 Heel Angle. The angle defined by the intersection of a vertical line through the center of a vessel and a line perpendicular to the surface of the water.

3.14.7 International Shore Connection. A universal connection complying with ASTM F 1121, *Standard Specification for International Shore Connections for Marine Fire Applications,* to which shoreside fire-fighting hose are to be connected.

3.14.8* Marine System. A sprinkler system installed on a ship, boat, or other floating structure that takes its supply from the water on which the vessel floats.

3.14.9* Marine Thermal Barrier. An assembly that is constructed of noncombustible materials and made intact with the main structure of the vessel, such as shell, structural bulkheads, and decks. A marine thermal barrier shall meet the requirements of a B-Class boundary. In addition, a marine thermal barrier shall be insulated such that, if tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* for 15 minutes, the average temperature of the unexposed side does not rise more than 250°F (193°C) above the original temperature, nor does the temperature at any one point, including any joint, rise more than 405°F (225°C) above the original temperature.

3.14.10 Supervision. A visual and audible alarm signal given at the central safety station to indicate when the system is in operation or when a condition that would impair the satisfactory operation of the system exists. Supervisory alarms shall give a distinct indication for each individual system component that is monitored.

3.14.11 Survival Angle. The maximum angle to which a vessel is permitted to heel after the assumed damage required by stability regulations is imposed.

3.14.12 Type 1 Stair. A fully enclosed stair that serves all levels of a vessel in which persons can be employed.

3.14.13 Marine Water Supply. The supply portion of the sprinkler system from the water pressure tank or the sea suction of the designated sprinkler system pump up to and including the valve that isolates the sprinkler system from these two water sources.

Chapter 4 General Requirements

4.1 Level of Protection. A building, where protected by an automatic sprinkler system installation, shall be provided with sprinklers in all areas except where specific sections of this standard permit the omission of sprinklers.

4.2 Limited Area Systems.

4.2.1 When partial sprinkler systems are installed, the requirements of this standard shall be used insofar as they are applicable.

4.2.2 The authority having jurisdiction shall be consulted in each case.

4.3 Owners' Certificate. The owner(s) of a building or structure where the fire sprinkler system is going to be installed or their authorized agent shall provide the sprinkler systems installer with the following information prior to the layout and detailing of the fire sprinkler system (*See Figure A.14.1(b)*):

(1) Intended use of the building including the materials within the building and the maximum height of any storage
(2) A preliminary plan of the building or structure along with the design concepts necessary to perform the layout and detail for the fire sprinkler system
(3) Any special knowledge of the water supply including known environmental conditions that might be responsible for microbiologically influenced corrosion (MIC)

Chapter 5 Classification of Occupancies and Commodities

5.1* Classification of Occupancies.

5.1.1 Occupancy classifications for this standard shall relate to sprinkler design, installation, and water supply requirements only.

5.1.2 Occupancy classifications shall not be intended to be a general classification of occupancy hazards.

5.2* Light Hazard Occupancies. Light hazard occupancies shall be defined as occupancies or portions of other occupancies where the quantity and/or combustibility of contents is low and fires with relatively low rates of heat release are expected.

5.3 Ordinary Hazard Occupancies.

5.3.1* Ordinary Hazard (Group 1). Ordinary hazard (Group 1) occupancies shall be defined as occupancies or portions of other occupancies where combustibility is low, quantity of combustibles is moderate, stockpiles of combustibles do not exceed 8 ft (2.4 m), and fires with moderate rates of heat release are expected.

5.3.2* Ordinary Hazard (Group 2). Ordinary hazard (Group 2) occupancies shall be defined as occupancies or portions of other occupancies where the quantity and combustibility of contents are moderate to high, stockpiles do not exceed 12 ft (3.7 m), and fires with moderate to high rates of heat release are expected.

5.4 Extra Hazard Occupancies.

5.4.1* Extra Hazard (Group 1). Extra hazard (Group 1) occupancies shall be defined as occupancies or portions of other occupancies where the quantity and combustibility of contents are very high and dust, lint, or other materials are present, introducing the probability of rapidly developing fires with high rates of heat release but with little or no combustible or flammable liquids.

5.4.2* Extra Hazard (Group 2). Extra hazard (Group 2) occupancies shall be defined as occupancies or portions of other occupancies with moderate to substantial amounts of flammable or combustible liquids or occupancies where shielding of combustibles is extensive.

5.5* Special Occupancy Hazards.

5.6* Commodity Classification. See Section C.2.

5.6.1 General.

5.6.1.1* Classification of Commodities.

5.6.1.1.1 Commodity classification and the corresponding protection requirements shall be determined based on the makeup of individual storage units (i.e., unit load, pallet load).

5.6.1.1.2 When specific test data of commodity classification by a nationally recognized testing agency are available, the data shall be permitted to be used in determining classification of commodities.

5.6.1.2 Mixed Commodities.

5.6.1.2.1 Protection requirements shall not be based on the overall commodity mix in a fire area.

5.6.1.2.2 Unless the requirements of 5.6.1.2.3 or 5.6.1.2.4 are met, mixed commodity storage shall be protected by the requirements for the highest classified commodity and storage arrangement.

5.6.1.2.3 The protection requirements for the lower commodity class shall be permitted to be utilized where all of the following are met:

(1) Up to 10 pallet loads of a higher hazard commodity, as described in 5.6.3 and 5.6.4, shall be permitted to be present in an area not exceeding 40,000 ft^2 (3716 m^2).
(2) The higher hazard commodity shall be randomly dispersed with no adjacent loads in any direction (including diagonally).
(3) Where the ceiling protection is based on Class I or Class II commodities, the allowable number of pallet loads for Class IV or Group A plastics shall be reduced to five.

5.6.1.2.4 Mixed Commodity Segregation. The protection requirements for the lower commodity class shall be permitted to be utilized in the area of lower commodity class, where the higher hazard material is confined to a designated area and

the area is protected to the higher hazard in accordance with the requirements of this standard.

5.6.2 Pallet Types.

5.6.2.1 When loads are palletized, the use of wooden or metal pallets shall be assumed in the classification of commodities.

5.6.2.2 For Class I through Class IV, when unreinforced polypropylene or high-density polyethylene plastic pallets are used, the classification of the commodity unit shall be increased one class (e.g., Class III will become Class IV and Class IV will become cartoned unexpanded Group A plastics).

5.6.2.3 For Class I through Class IV, when reinforced polypropylene or high-density polyethylene plastic pallets are used, the classification of the commodity unit shall be increased two classes (e.g., Class II will become Class IV and Class III will become cartoned unexpanded Group A plastic commodity). Reinforced polypropylene or reinforced high-density polyethylene plastic pallets shall be marked with a molded symbol to indicate that the pallet is reinforced.

5.6.2.4 For Class I through Class IV when other than polypropylene or high-density polyethylene plastic pallets are used, the classification of the commodity unit shall be determined by specific testing conducted by a national testing laboratory or shall be increased two classes.

5.6.2.5 No increase in the commodity classification shall be required for Group A plastic commodities stored on plastic pallets.

5.6.2.6 For ceiling-only sprinkler protection, the requirements of 5.6.2.2 and 5.6.2.3 shall not apply where plastic pallets are used and where the sprinkler system uses spray sprinklers with a K-factor of 16.8.

5.6.2.7 The requirements of 5.6.2.2 through 5.6.2.4 shall not apply to nonwood pallets that have demonstrated a fire hazard that is equal to or less than wood pallets and are listed as such.

5.6.3* Commodity Classes.

5.6.3.1* Class I. A Class I commodity shall be defined as a noncombustible product that meets one of the following criteria:

(1) Placed directly on wooden pallets
(2) Placed in single-layer corrugated cartons, with or without single-thickness cardboard dividers, with or without pallets
(3) Shrink-wrapped or paper-wrapped as a unit load with or without pallets

5.6.3.2* Class II. A Class II commodity shall be defined as a noncombustible product that is in slatted wooden crates, solid wood boxes, multiple-layered corrugated cartons, or equivalent combustible packaging material, with or without pallets.

5.6.3.3* Class III.

5.6.3.3.1 A Class III commodity shall be defined as a product fashioned from wood, paper, natural fibers, or Group C plastics with or without cartons, boxes, or crates and with or without pallets.

5.6.3.3.2 A Class III commodity shall be permitted to contain a limited amount (5 percent by weight or volume or less) of Group A or Group B plastics.

5.6.3.4* Class IV.

5.6.3.4.1 A Class IV commodity shall be defined as a product, with or without pallets, that meets one of the following criteria:

(1) Constructed partially or totally of Group B plastics
(2) Consists of free-flowing Group A plastic materials
(3) Contains within itself or its packaging an appreciable amount (5 percent to 15 percent by weight or 5 percent to 25 percent by volume) of Group A plastics

5.6.3.4.2 The remaining materials shall be permitted to be metal, wood, paper, natural or synthetic fibers, or Group B or Group C plastics.

5.6.4* Classification of Plastics, Elastomers, and Rubber. Plastics, elastomers, and rubber shall be classified as Group A, Group B, or Group C.

5.6.4.1* Group A. The following materials shall be classified as Group A:

(1) ABS (acrylonitrile-butadiene-styrene copolymer)
(2) Acetal (polyformaldehyde)
(3) Acrylic (polymethyl methacrylate)
(4) Butyl rubber
(5) EPDM (ethylene-propylene rubber)
(6) FRP (fiberglass-reinforced polyester)
(7) Natural rubber (if expanded)
(8) Nitrile-rubber (acrylonitrile-butadiene-rubber)
(9) PET (thermoplastic polyester)
(10) Polybutadiene
(11) Polycarbonate
(12) Polyester elastomer
(13) Polyethylene
(14) Polypropylene
(15) Polystyrene
(16) Polyurethane
(17) PVC (polyvinyl chloride — highly plasticized, with plasticizer content greater than 20 percent) (rarely found)
(18) SAN (styrene acrylonitrile)
(19) SBR (styrene-butadiene rubber)

5.6.4.2 Group B. The following materials shall be classified as Group B:

(1) Cellulosics (cellulose acetate, cellulose acetate butyrate, ethyl cellulose)
(2) Chloroprene rubber
(3) Fluoroplastics (ECTFE — ethylene-chlorotrifluoro-ethylene copolymer; ETFE — ethylene-tetrafluoroethylene-copolymer; FEP — fluorinated ethylene-propylene copolymer)
(4) Natural rubber (not expanded)
(5) Nylon (nylon 6, nylon 6/6)
(6) Silicone rubber

5.6.4.3 Group C. The following materials shall be classified as Group C:

(1) Fluoroplastics (PCTFE — polychlorotrifluoroethylene; PTFE — polytetrafluoroethylene)
(2) Melamine (melamine formaldehyde)
(3) Phenolic
(4) PVC (polyvinyl chloride — flexible — PVCs with plasticizer content up to 20 percent)
(5) PVDC (polyvinylidene chloride)
(6) PVDF (polyvinylidene fluoride)
(7) PVF (polyvinyl fluoride)
(8) Urea (urea formaldehyde)

5.6.5* Classification of Rolled Paper Storage. For the purposes of this standard, the classifications of paper described in 5.6.5.1 through 5.6.5.4 shall apply and shall be used to determine the sprinkler system design criteria.

5.6.5.1 Heavyweight Class. Heavyweight class shall be defined so as to include paperboard and paper stock having a basis weight [weight per 1000 ft^2 (92.9 m^2)] of 20 lb (9.1 kg).

5.6.5.2 Mediumweight Class. Mediumweight class shall be defined so as to include all the broad range of papers having a basis weight [weight per 1000 ft^2 (92.9 m^2)] of 10 lb to 20 lb (4.5 kg to 9.1 kg).

5.6.5.3 Lightweight Class. Lightweight class shall be defined so as to include all papers having a basis weight [weight per 1000 ft^2 (92.9 m^2)] of 10 lb (4.5 kg).

5.6.5.4 Tissue.

5.6.5.4.1 Tissue shall be defined so as to include the broad range of papers of characteristic gauzy texture, which, in some cases, are fairly transparent.

5.6.5.4.2 For the purposes of this standard, tissue shall be defined as the soft, absorbent type, regardless of basis weight — specifically, crepe wadding and the sanitary class including facial tissue, paper napkins, bathroom tissue, and toweling.

Chapter 6 System Components and Hardware

6.1 General. This chapter provides requirements for correct use of sprinkler system components.

6.1.1* Listing.

6.1.1.1 Materials or devices not specifically designated by this standard shall be used in accordance with all conditions, requirements, and limitations of their special listing. All special listing requirements shall be included and identified in the product submittal literature and installation instructions.

6.1.1.2 Unless the requirements of 6.1.1.3, 6.1.1.4, or 6.1.1.5 are met, all materials and devices essential to successful system operation shall be listed.

6.1.1.3 Equipment as permitted in Table 6.3.1.1 and Table 6.4.1 shall not be required to be listed.

6.1.1.4 Materials meeting the requirements of 9.1.1.2, 9.1.1.4.2, and 9.1.1.4.3 shall not be required to be listed.

6.1.1.5 Components that do not affect system performance such as drain piping, drain valves, and signs shall not be required to be listed.

6.1.2 Reconditioned Components.

6.1.2.1 The use of reconditioned valves and devices as replacement equipment in existing systems shall be permitted.

6.1.2.2 Reconditioned sprinklers shall not be permitted to be utilized on any new or existing system.

6.1.3 Rated Pressure. System components shall be rated for the maximum system working pressure to which they are exposed but shall not be rated at less than 175 psi (12.1 bar) for components installed aboveground and 150 psi (10.4 bar) for components installed underground.

6.2 Sprinklers.

6.2.1 General. Only new sprinklers shall be installed.

6.2.2* Sprinkler Identification.

6.2.2.1 All sprinklers shall be permanently marked with a one- or two-character manufacturer symbol, followed by three or four numbers, so as to identify a unique sprinkler identification for every change in orifice size or shape, deflector characteristic, pressure rating, and thermal sensitivity.

6.2.2.2 The requirements of 6.2.2 shall become effective on January 1, 2001.

6.2.3 Sprinkler Discharge Characteristics.

6.2.3.1* General. Unless the requirements of 6.2.3.2, 6.2.3.3, or 6.2.3.4 are met, the K-factor, relative discharge, and marking identification for sprinklers having different orifice sizes shall be in accordance with Table 6.2.3.1.

6.2.3.2 Pipe Threads. Listed sprinklers having pipe threads different from those shown in Table 6.2.3.1 shall be permitted.

6.2.3.3 K-Factors Greater Than 28. Sprinklers listed with nominal K-factors greater than 28 shall increase the flow by 100 percent increments when compared with a nominal K-5.6 sprinkler.

6.2.3.4 Residential Sprinklers. Residential sprinklers shall be permitted with K-factors other than those specified in Table 6.2.3.1.

6.2.3.5 Large Drop and ESFR K-Factors. Large drop and ESFR sprinklers shall have a minimum nominal K-factor of 11.2.

6.2.3.6 ESFR Orifice Size. ESFR sprinkler orifice size shall be selected as appropriate for the hazard. *(See Chapter 12.)*

6.2.4 Occupancy Limitations. Unless the requirements of 6.2.4.1 or 6.2.4.2 are met, sprinklers shall not be listed for protection of a portion of an occupancy classification.

6.2.4.1 Residential Sprinklers. Residential sprinklers shall be permitted to be listed for portions of residential occupancies as defined in 8.4.5.1.

6.2.4.2 Special Sprinklers. Special sprinklers shall be permitted to be listed for protection of a specific construction feature in a portion of an occupancy classification. *(See 8.4.9.)*

6.2.5* Temperature Characteristics.

6.2.5.1 Automatic sprinklers shall have their frame arms, deflector, coating material, or liquid bulb colored in accordance with the requirements of Table 6.2.5.1 or the requirements of 6.2.5.2, 6.2.5.3, 6.2.5.4, or 6.2.5.5.

6.2.5.2 A dot on the top of the deflector, the color of the coating material, or colored frame arms shall be permitted for color identification of corrosion-resistant sprinklers.

6.2.5.3 Color identification shall not be required for ornamental sprinklers such as factory-plated or factory-painted sprinklers or for recessed, flush, or concealed sprinklers.

6.2.5.4 The frame arms of bulb-type sprinklers shall not be required to be color coded.

6.2.5.5 The liquid in bulb-type sprinklers shall be color coded in accordance with Table 6.2.5.1.

Table 6.2.3.1 Sprinkler Discharge Characteristics Identification

Nominal K-factor [gpm/(psi)$^{1/2}$]	K-factor Range [gpm/(psi)$^{1/2}$]	K-factor Range [dm^3/min/(kPa)$^{1/2}$]	Percent of Nominal K-5.6 Discharge	Thread Type
1.4	1.3–1.5	1.9–2.2	25	½ in. NPT
1.9	1.8–2.0	2.6–2.9	33.3	½ in. NPT
2.8	2.6–2.9	3.8–4.2	50	½ in. NPT
4.2	4.0–4.4	5.9–6.4	75	½ in. NPT
5.6	5.3–5.8	7.6–8.4	100	½ in. NPT
8.0	7.4–8.2	10.7–11.8	140	¾ in. NPT or ½ in. NPT
11.2	11.0–11.5	15.9–16.6	200	½ in. NPT or ¾ in. NPT
14.0	13.5–14.5	19.5–20.9	250	¾ in. NPT
16.8	16.0–17.6	23.1–25.4	300	¾ in. NPT
19.6	18.6–20.6	27.2–30.1	350	1 in. NPT
22.4	21.3–23.5	31.1–34.3	400	1 in. NPT
25.2	23.9–26.5	34.9–38.7	450	1 in. NPT
28.0	26.6–29.4	38.9–43.0	500	1 in. NPT

Table 6.2.5.1 Temperature Ratings, Classifications, and Color Codings

Maximum Ceiling Temperature		Temperature Rating				
°F	°C	°F	°C	Temperature Classification	Color Code	Glass Bulb Colors
100	38	135–170	57–77	Ordinary	Uncolored or black	Orange or red
150	66	175–225	79–107	Intermediate	White	Yellow or green
225	107	250–300	121–149	High	Blue	Blue
300	149	325–375	163–191	Extra high	Red	Purple
375	191	400–475	204–246	Very extra high	Green	Black
475	246	500–575	260–302	Ultra high	Orange	Black
625	329	650	343	Ultra high	Orange	Black

6.2.6 Special Coatings.

6.2.6.1* Corrosion Resistant.

6.2.6.1.1 Listed corrosion-resistant sprinklers shall be installed in locations where chemicals, moisture, or other corrosive vapors sufficient to cause corrosion of such devices exist.

6.2.6.1.2* Unless the requirements of 6.2.6.1.3 are met, corrosion-resistant coatings shall be applied only by the manufacturer of the sprinkler and in accordance with the requirements of 6.2.6.1.3.

6.2.6.1.3 Any damage to the protective coating occurring at the time of installation shall be repaired at once using only the coating of the manufacturer of the sprinkler in the approved manner so that no part of the sprinkler will be exposed after installation has been completed.

6.2.6.2* Painting.

6.2.6.2.1 Sprinklers shall only be painted by the sprinkler *manufacturer.*

6.2.6.2.2 Where sprinklers have had paint applied by other than the sprinkler manufacturer, they shall be replaced with new listed sprinklers of the same characteristics, including orifice size, thermal response, and water distribution.

6.2.6.3 Ornamental Finishes.

6.2.6.3.1 Ornamental finishes shall only be applied to sprinklers, and if applicable their concealed cover plates, by the sprinkler manufacturer.

6.2.6.3.2 Sprinklers shall be specifically listed with ornamental finishes where utilized.

6.2.6.4 Protective Coverings.

6.2.6.4.1 Sprinklers protecting spray areas and mixing rooms in resin application areas shall be protected against overspray residue so that they will operate in the event of fire.

6.2.6.4.2 Where protected in accordance with 6.2.6.4.1, cellophane bags having a thickness of 0.003 in. (0.076 mm) or less or thin paper bags shall be used.

6.2.6.4.3 Coverings shall be replaced periodically so that heavy deposits of residue do not accumulate.

6.2.6.4.4 Sprinklers that have been painted or coated shall be replaced in accordance with the requirements of 6.2.6.2.2.

6.2.7 Escutcheons and Cover Plates.

6.2.7.1 Nonmetallic escutcheons shall be listed.

6.2.7.2* Escutcheons used with recessed, flush-type, or concealed sprinklers shall be part of a listed sprinkler assembly.

6.2.7.3 Cover plates used with concealed sprinklers shall be part of the listed sprinkler assembly.

6.2.8* Guards and Shields. Sprinklers subject to mechanical injury shall be protected with listed guards.

6.2.9 Stock of Spare Sprinklers.

6.2.9.1* A supply of at least six spare sprinklers (never fewer than six) shall be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced.

6.2.9.2 The sprinklers shall correspond to the types and temperature ratings of the sprinklers in the property.

6.2.9.3 The sprinklers shall be kept in a cabinet located where the temperature to which they are subjected will at no time exceed 100°F (38°C).

6.2.9.4 Where dry sprinklers of different lengths are installed, spare dry sprinklers shall not be required, provided that a means of returning the system to service is furnished.

6.2.9.5 The stock of spare sprinklers shall include all types and ratings installed and shall be as follows:

(1) For protected facilities having under 300 sprinklers — no fewer than six sprinklers
(2) For protected facilities having 300 to 1000 sprinklers — no fewer than 12 sprinklers
(3) For protected facilities having over 1000 sprinklers — no fewer than 24 sprinklers

6.2.9.6 A special sprinkler wrench shall be provided and kept in the cabinet to be used in the removal and installation of sprinklers. One sprinkler wrench shall be provided for each type of sprinkler installed.

6.3 Aboveground Pipe and Tube.

6.3.1 General.

6.3.1.1 Pipe or tube shall meet or exceed one of the standards in Table 6.3.1.1 or be in accordance with 6.3.6.

6.3.1.2 Steel pipe shall be in accordance with 6.3.2, 6.3.3, or 6.3.4.

6.3.1.3 Copper tube shall be in accordance with 6.3.5.

6.3.1.4 Chlorinated polyvinyl chloride (CPVC) and polybutylene pipe shall be in accordance with 6.3.6 and with the portions of the ASTM standards specified in Table 6.3.6.1 that apply to fire protection service.

6.3.2* Steel Pipe — Welded or Roll-Grooved. When steel pipe referenced in Table 6.3.1.1 is used and joined by welding as referenced in 6.5.2 or by roll-grooved pipe and fittings as referenced in 6.5.3, the minimum nominal wall thickness for pressures up to 300 psi (20.7 bar) shall be in accordance with Schedule 10 for pipe sizes up to 5 in. (127 mm), 0.134 in. (3.40 mm) for 6-in. (152-mm) pipe, and 0.188 in. (4.78 mm) for 8- and 10-in. (203- and 254-mm) pipe.

Table 6.3.1.1 Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Ferrous Piping (Welded and Seamless)	
Specification for black and hot-dipped zinc-coated (galvanized) welded and seamless steel pipe for fire protection use	ASTM A 795
Specification for welded and seamless steel pipe	ANSI/ASTM A 53
Wrought steel pipe	ANSI/ASME B36.10M
Specification for electric-resistance-welded steel pipe	ASTM A 135
Copper Tube (Drawn, Seamless)	
Specification for seamless copper tube	ASTM B 75
Specification for seamless copper water tube	ASTM B 88
Specification for general requirements for wrought seamless copper and copper-alloy tube	ASTM B 251
Fluxes for soldering applications of copper and copper-alloy tube	ASTM B 813
Brazing filler metal (classification BCuP-3 or BCuP-4)	AWS A5.8
Solder metal, 95-5 (tin-antimony-Grade 95TA)	ASTM B 32
Alloy materials	ASTM B 446

6.3.3 Steel Pipe — Threaded. When steel pipe referenced in Table 6.3.1.1 is joined by threaded fittings referenced in 6.5.1 or by fittings used with pipe having cut grooves, the minimum wall thickness shall be in accordance with Schedule 30 pipe [in sizes 8 in. (203 mm) and larger] or Schedule 40 pipe [in sizes less than 8 in. (203 mm)] for pressures up to 300 psi (20.7 bar).

6.3.4 Specially Listed Steel Pipe. Pressure limitations and wall thickness for steel pipe specially listed in accordance with 6.3.6 shall be permitted to be in accordance with the pipe listing requirements.

6.3.5* Copper Tube. Copper tube as specified in the standards listed in Table 6.3.1.1 shall have a wall thickness of Type K, Type L, or Type M where used in sprinkler systems.

6.3.6* Listed Pipe and Tubing.

6.3.6.1 Other types of pipe or tube investigated for suitability in automatic sprinkler installations and listed for this service, including but not limited to polybutylene, CPVC, and steel, differing from that provided in Table 6.3.6.1 shall be permitted where installed in accordance with their listing limitations, including installation instructions.

Table 6.3.6.1 Specially Listed Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Nonmetallic piping specification for special listed chlorinated polyvinyl chloride (CPVC) pipe	ASTM F 442
Specification for special listed polybutylene (PB) pipe	ASTM D 3309

6.3.6.2 Pipe or tube listed for light hazard occupancies shall be permitted to be installed in ordinary hazard rooms of otherwise light hazard occupancies where the room does not exceed 400 ft^2 (37 m^2).

6.3.6.3 Pipe or tube shall not be listed for portions of an occupancy classification.

6.3.6.4 Bending of listed pipe and tubing shall be permitted as allowed by the listing.

6.3.7 Pipe Bending.

6.3.7.1 Bending of Schedule 10 steel pipe, or any steel pipe of wall thickness equal to or greater than Schedule 10 and Types K and L copper tube, shall be permitted when bends are made with no kinks, ripples, distortions, or reductions in diameter or any noticeable deviations from round.

6.3.7.2 For Schedule 40 and copper tubing, the minimum radius of a bend shall be six pipe diameters for pipe sizes 2 in. (51 mm) and smaller and five pipe diameters for pipe sizes 2½ in. (64 mm) and larger.

6.3.7.3 For all other steel pipe, the minimum radius of a bend shall be 12 pipe diameters for all sizes.

6.3.8 Pipe Identification.

6.3.8.1 All pipe, including specially listed pipe allowed by 6.3.6, shall be marked continuously along its length by the manufacturer in such a way as to properly identify the type of pipe.

6.3.8.2 Pipe identification shall include the manufacturer's name, model designation, or schedule.

6.4 Fittings.

6.4.1 Fittings used in sprinkler systems shall meet or exceed the standards in Table 6.4.1 or be in accordance with 6.4.2 or 6.4.3.

6.4.2 In addition to the standards in Table 6.4.1, CPVC fittings shall also be in accordance with 6.4.3 and with the portions of the ASTM standards specified in Table 6.4.3 that apply to fire protection service.

6.4.3* Other types of fittings investigated for suitability in automatic sprinkler installations and listed for this service including, but not limited to, polybutylene, CPVC, and steel differing from that provided in Table 6.4.3, shall be permitted when installed in accordance with their listing limitations, including installation instructions.

6.4.4* Fitting Pressure Limits.

6.4.4.1 Standard weight pattern cast-iron fittings 2 in. (51 mm) in size and smaller shall be permitted where pressures do not exceed 300 psi (20.7 bar).

Table 6.4.1 Fittings Materials and Dimensions

Materials and Dimensions	Standard
Cast Iron	
Cast iron threaded fittings, Class 125 and 250	ASME B16.4
Cast iron pipe flanges and flanged fittings	ASME B16.1
Malleable Iron	
Malleable iron threaded fittings, Class 150 and 300 steel	ASME B16.3
Factory-made wrought steel buttweld fittings	ASME B16.9
Buttwelding ends for pipe, valves, flanges, and fittings	ASME B16.25
Specification for piping fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures	ASTM A 234
Steel pipe flanges and flanged fittings	ASME B16.5
Forged steel fittings, socket welded and threaded copper	ASME B16.11
Wrought copper and copper alloy solder joint pressure fittings	ASME B16.22
Cast copper alloy solder joint pressure fittings	ASME B16.18

Table 6.4.3 Specially Listed Fittings Materials and Dimensions

Materials and Dimensions	Standard
Chlorinated polyvinyl chloride (CPVC) specification for schedule 80 CPVC threaded fittings	ASTM F 437
Specification for schedule 40 CPVC socket-type fittings	ASTM F 438
Specification for schedule 80 CPVC socket-type fittings	ASTM F 439

6.4.4.2 Standard weight pattern malleable iron fittings 6 in. (152 mm) in size and smaller shall be permitted where pressures do not exceed 300 psi (20.7 bar).

6.4.4.3 Listed fittings shall be permitted for system pressures up to the limits specified in their listings.

6.4.4.4 Fittings not meeting the requirements of 6.4.4.1 through 6.4.4.3 shall be extra-heavy pattern where pressures exceed 175 psi (12.1 bar).

6.4.5* Couplings and Unions.

6.4.5.1 Screwed unions shall not be used on pipe larger than 2 in. (51 mm).

6.4.5.2 Couplings and unions of other than screwed-type shall be of types listed specifically for use in sprinkler systems.

6.4.6 Reducers and Bushings.

6.4.6.1 Unless the requirements of 6.4.6.2 or 6.4.6.3 are met, a one-piece reducing fitting shall be used wherever a change is made in the size of the pipe.

6.4.6.2 Hexagonal or face bushings shall be permitted in reducing the size of openings of fittings when standard fittings of the required size are not available.

6.4.6.3 Hexagonal bushings as permitted in 8.14.19.2 shall be permitted to be used.

6.5 Joining of Pipe and Fittings.

6.5.1 Threaded Pipe and Fittings.

6.5.1.1 All threaded pipe and fittings shall have threads cut to ASME B1.20.1, *Pipe Threads, General Purpose (Inch).*

6.5.1.2* Steel pipe with wall thicknesses less than Schedule 30 [in sizes 8 in. (203 mm) and larger] or Schedule 40 [in sizes less than 8 in. (203 mm)] shall only be permitted to be joined by threaded fittings where the threaded assembly is investigated for suitability in automatic sprinkler installations and listed for this service.

6.5.1.3 Joint compound or tape shall be applied only to male threads.

6.5.2* Welded Pipe and Fittings.

6.5.2.1 Welding methods that comply with the applicable requirements of AWS B2.1, *Specification for Welding Procedure and Performance Qualification,* shall be permitted as means of joining fire protection piping.

6.5.2.1.1 Where outlets are welded in pipe using listed welding outlet fittings, partial joint penetration (groove/fillet) shall be acceptable when performed in accordance with the requirements of 6.5.2.1.

6.5.2.1.2 Where slip-on flanges are welded to pipe, fillet welds shall be acceptable where such welds are used along both circumferences where the flange contacts the pipe.

6.5.2.2* Unless the requirements of 6.5.2.3 are met, sprinkler piping shall be shop welded.

6.5.2.3 Where the design specifications call for all or part of the piping to be welded in place, welding of sprinkler piping in place shall be permitted where the welding process is performed in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* and the mechanical fittings required by 8.14.16 and 8.14.21 are provided.

6.5.2.4 Welding of tabs for longitudinal earthquake bracing to in-place piping shall be permitted where the welding process is performed in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work.*

6.5.2.5 Welded fittings used to join pipe shall be listed fabricated fittings or manufactured in accordance with Table 6.4.1.

6.5.2.6 Fittings referenced in 6.5.2.5 shall be joined in conformance with a qualified welding procedure as set forth in this section and shall be an acceptable product under this standard, provided that materials and wall thickness are compatible with other sections of this standard.

6.5.2.7 Fittings shall not be required where pipe ends are butt welded in accordance with the requirements of 6.5.2.1.

6.5.2.8 No welding shall be performed if there is impingement of rain, snow, sleet, or high wind on the weld area of the pipe product.

6.5.2.9 When welding is performed, the following procedures shall be completed:

(1)*Holes in piping for outlets shall be cut to the full inside diameter of fittings prior to welding in place of the fittings.
(2) Discs shall be retrieved.
(3) Openings cut into piping shall be smooth bore, and all internal slag and welding residue shall be removed.
(4) Fittings shall not penetrate the internal diameter of the piping.
(5) Steel plates shall not be welded to the ends of piping or fittings.
(6) Fittings shall not be modified.
(7) Nuts, clips, eye rods, angle brackets, or other fasteners shall not be welded to pipe or fittings, except as permitted in 6.5.2.10.

6.5.2.10 Tabs for longitudinal earthquake braces shall be permitted to be welded directly to the sprinkler pipe.

6.5.2.11 When the pipe size in a run of piping is reduced, a reducing fitting designed for that purpose shall be used in accordance with the requirements of 6.5.2.3.

6.5.2.12 Torch cutting and welding shall not be permitted as a means of modifying or repairing sprinkler systems.

6.5.2.13 Qualifications.

6.5.2.13.1 A welding procedure shall be prepared and qualified by the contractor or fabricator before any welding is done.

6.5.2.13.2 Qualification of the welding procedure to be used and the performance of all welders and welding operators shall be required and shall meet or exceed the requirements of AWS B2.1, *Specification for Welding Procedure and Performance Qualification,* except as permitted by 6.5.2.13.3.

6.5.2.13.3 Successful procedure qualification of complete joint penetration groove welds shall qualify partial joint penetration (groove/fillet) welds and fillet welds in accordance with the provisions of this standard.

6.5.2.13.4 Welding procedures qualified under standards recognized by previous editions of this standard shall be permitted to be continued in use.

6.5.2.13.5 Contractors or fabricators shall be responsible for all welding they produce.

6.5.2.13.6 Each contractor or fabricator shall have available to the authority having jurisdiction an established written quality assurance procedure ensuring compliance with the requirements of 6.5.2.9.

6.5.2.14 Records.

6.5.2.14.1 Welders or welding machine operators shall, upon completion of each weld, stamp an imprint of their identification into the side of the pipe adjacent to the weld.

6.5.2.14.2 Contractors or fabricators shall maintain certified records, which shall be available to the authority having jurisdiction, of the procedures used and the welders or welding machine operators employed by them, along with their welding identification imprints.

6.5.2.14.3 Records shall show the date and the results of procedure and performance qualifications.

6.5.3 Groove Joining Methods.

6.5.3.1 Pipe joined with grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves.

6.5.3.2 Grooves cut or rolled on pipe shall be dimensionally compatible with the fittings.

6.5.3.3 Grooved fittings including gaskets used on dry pipe systems shall be listed for dry pipe service.

6.5.4* Brazed and Soldered Joints.

6.5.4.1 Solder joints, where permitted, shall be fabricated in accordance with the methods and procedures listed in ASTM B 828, *Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.*

6.5.4.2 Unless the requirements of 6.5.4.3 or 6.5.4.4 are met, joints for the connection of copper tube shall be brazed.

6.5.4.3 Solder joints shall be permitted for exposed wet pipe systems in light hazard occupancies where the temperature classification of the installed sprinklers is of the ordinary- or intermediate-temperature classification.

6.5.4.4 Solder joints shall be permitted for wet pipe systems in light hazard and ordinary hazard (Group 1) occupancies where the piping is concealed, irrespective of sprinkler temperature ratings.

6.5.4.5* Soldering fluxes shall be in accordance with Table 6.3.1.1.

6.5.4.6 Brazing fluxes, if used, shall not be of a highly corrosive type.

6.5.5 Other Joining Methods. Other joining methods investigated for suitability in automatic sprinkler installations and listed for this service shall be permitted where installed in accordance with their listing limitations, including installation instructions.

6.5.6 End Treatment.

6.5.6.1 After cutting, pipe ends shall have burrs and fins removed.

6.5.6.2 Pipe used with listed fittings and its end treatment shall be in accordance with the fitting manufacturer's installation instructions and the fitting's listing.

6.6* Hangers. Hangers shall be in accordance with the requirements of Section 9.1.

6.7 Valves.

6.7.1 General.

6.7.1.1 Valve Pressure Requirements. When water pressures exceed 175 psi (12.1 bar), valves shall be used in accordance with their pressure ratings.

6.7.1.2 Valve Closure Time. Listed indicating valves shall not close in less than 5 seconds when operated at maximum possible speed from the fully open position.

6.7.1.3 Listed Indicating Valves. Unless the requirements of 6.7.1.3.1, 6.7.1.3.2, or 6.7.1.3.3 are met, all valves controlling connections to water supplies and to supply pipes to sprinklers shall be listed indicating valves.

6.7.1.3.1 A listed underground gate valve equipped with a listed indicator post shall be permitted.

6.7.1.3.2 A listed water control valve assembly with a reliable position indication connected to a remote supervisory station shall be permitted.

6.7.1.3.3 A nonindicating valve, such as an underground gate valve with approved roadway box, complete with T-wrench, and where accepted by the authority having jurisdiction, shall be permitted.

6.7.2 Wafer-Type Valves. Wafer-type valves with components that extend beyond the valve body shall be installed in a manner that does not interfere with the operation of any system components.

6.7.3 Drain Valves and Test Valves. Drain valves and test valves shall be approved.

6.7.4* Identification of Valves.

6.7.4.1 All control, drain, and test connection valves shall be provided with permanently marked weatherproof metal or rigid plastic identification signs.

6.7.4.2 The identification sign shall be secured with corrosion-resistant wire, chain, or other approved means.

6.7.4.3 The control valve sign shall identify the portion of the building served.

6.8 Fire Department Connections.

6.8.1 Unless the requirements of 6.8.2 or 6.8.3 are met, the fire department connection(s) shall use an NH internal threaded swivel fitting(s) with an NH standard thread(s), where at least one of the connections shall be the "2.5-7.5 NH standard thread," as specified in NFPA 1963, *Standard for Fire Hose Connections.*

6.8.2 Where local fire department connections do not conform to NFPA 1963, *Standard for Fire Hose Connections,* the authority having jurisdiction shall be permitted to designate the connection to be used.

6.8.3 The use of threadless couplings shall be permitted where required by the authority having jurisdiction and where listed for such use.

6.8.4 Fire department connections shall be equipped with listed plugs or caps, properly secured and arranged for easy removal by fire departments.

6.8.5 Fire department connections shall be of an approved type.

6.9 Waterflow Alarms.

6.9.1 General. Waterflow alarm apparatus shall be listed for the service and so constructed and installed that any flow of water from a sprinkler system equal to or greater than that from a single automatic sprinkler of the smallest orifice size installed on the system will result in an audible alarm on the premises within 5 minutes after such flow begins and until such flow stops.

6.9.2 Waterflow Detecting Devices.

6.9.2.1 Wet Pipe Systems. The alarm apparatus for a wet pipe system shall consist of a listed alarm check valve or other listed waterflow-detecting alarm device with the necessary attachments required to give an alarm.

6.9.2.2 Dry Pipe Systems.

6.9.2.2.1 The alarm apparatus for a dry pipe system shall consist of listed alarm attachments to the dry pipe valve.

6.9.2.2.2 Where a dry pipe valve is located on the system side of an alarm valve, connection of the actuating device of the alarms for the dry pipe valve to the alarms on the wet pipe system shall be permitted.

6.9.2.3 Preaction and Deluge Systems. The alarm apparatus for deluge and preaction systems shall consist of alarms actuated independently by the detection system and the flow of water.

6.9.2.4* Paddle-Type Waterflow Devices. Paddle-type waterflow alarm indicators shall be installed in wet systems only.

6.9.3 Attachments — General.

6.9.3.1* An alarm unit shall include a listed mechanical alarm, horn, or siren or a listed electric gong, bell, speaker, horn, or siren.

6.9.3.2* Outdoor water motor-operated or electrically operated bells shall be weatherproofed and guarded.

6.9.3.3 All piping to water motor-operated devices shall be galvanized or brass or other corrosion-resistant material acceptable under this standard and of a size not less than ¾ in. (19 mm).

6.9.3.4 Piping between the sprinkler system and a pressure actuated alarm-initiating device shall be galvanized or of nonferrous metal or other approved corrosion-resistant material of not less than ⅜ in. (9.5 mm) nominal pipe size.

6.9.4* Attachments — Electrically Operated.

6.9.4.1 Electrically operated alarm attachments forming part of an auxiliary, central station, local protective, proprietary, or remote station signaling system shall be installed in accordance with *NFPA 72®*, *National Fire Alarm Code®*.

6.9.4.2 Sprinkler waterflow alarm systems that are not part of a required protective signaling system shall not be required to be supervised and shall be installed in accordance with NFPA 70, *National Electrical Code®*, Article 760.

6.9.4.3 Outdoor electric alarm devices shall be listed for outdoor use.

6.9.5 Alarm Device Drains. Drains from alarm devices shall be so arranged that there will be no overflowing at the alarm apparatus, at domestic connections, or elsewhere with the sprinkler drains wide open and under system pressure. *(See 8.15.2.6.)*

Chapter 7 System Requirements

7.1 Wet Pipe Systems.

7.1.1 Pressure Gauges.

7.1.1.1 A listed pressure gauge conforming to 8.16.3 shall be installed in each system riser.

7.1.1.2 Pressure gauges shall be installed above and below each alarm check valve or system riser check valve where such devices are present.

7.1.2 Relief Valves.

7.1.2.1 Unless the requirements of 7.1.2.2 are met, a gridded wet pipe system shall be provided with a relief valve not less than ¼ in. (6.4 mm) in size set to operate at 175 psi (12.1 bar) or 10 psi (0.7 bar) in excess of the maximum system pressure, whichever is greater.

7.1.2.2 Where auxiliary air reservoirs are installed to absorb pressure increases, a relief valve shall not be required.

7.1.3 Auxiliary Systems. A wet pipe system shall be permitted to supply an auxiliary dry pipe, preaction, or deluge system, provided the water supply is adequate.

7.2* Dry Pipe Systems.

7.2.1 Pressure Gauges. Listed pressure gauges conforming with 8.16.3 shall be connected as follows:

(1) On the water side and air side of the dry pipe valve
(2) At the air pump supplying the air receiver where one is provided
(3) At the air receiver where one is provided
(4) In each independent pipe from air supply to dry pipe system
(5) At exhausters and accelerators

7.2.2 Sprinklers. The following types of sprinklers and arrangements shall be permitted for dry pipe systems:

(1) Upright sprinklers
(2)*Listed dry sprinklers
(3) Pendent sprinklers and sidewall sprinklers installed on return bends, where the sprinklers, return bend, and branch line piping are in an area maintained at or above 40°F (4°C)
(4) Horizontal sidewall sprinklers, installed so that water is not trapped

7.2.3* Size of Systems — Volume Limitations.

7.2.3.1* Unless the requirements of 7.2.3.2 or 7.2.3.3 are met, not more than 750 gal (2839 L) system capacity shall be controlled by one dry pipe valve.

7.2.3.2 Piping volume shall be permitted to exceed the requirements of 7.2.3.1 where the system design is such that water is delivered to the system test connection in not more than 60 seconds, starting at the normal air pressure on the system and at the time of fully opened inspection test connection.

7.2.3.3 Piping volume shall be permitted to exceed the requirements of 7.2.3.1 where dry systems are calculated for water delivery in accordance with 11.2.3.9.

7.2.3.4 Check valves shall not be used to subdivide the dry pipe system.

7.2.3.5 Gridded dry pipe systems shall not be installed.

7.2.4 Quick-Opening Devices.

7.2.4.1 Unless the requirements of 7.2.4.2 are met, dry pipe valves shall be provided with a listed quick-opening device where system capacity exceeds 500 gal (1893 L).

7.2.4.2 A quick-opening device shall not be required where water is delivered to the system test connection in not more than 60 seconds, starting at the normal air pressure on the system and at the time of fully opened inspection test connection.

7.2.4.3 The quick-opening device shall be located as close as practical to the dry pipe valve.

7.2.4.4 To protect the restriction orifice and other operating parts of the quick-opening device against submergence, the connection to the riser shall be above the point at which water (priming water and back drainage) is expected when the dry

pipe valve and quick-opening device are set, except where design features of the particular quick-opening device make these requirements unnecessary.

7.2.4.5 A soft disc globe or angle valve shall be installed in the connection between the dry pipe sprinkler riser and the quick-opening device.

7.2.4.6 A check valve shall be installed between the quick-opening device and the intermediate chamber of the dry pipe valve.

7.2.4.7 If the quick-opening device requires pressure feedback from the intermediate chamber, a valve type that will clearly indicate whether it is opened or closed shall be permitted in place of that check valve.

7.2.4.8 Where a valve is utilized in accordance with 7.2.4.7, the valve shall be constructed so that it can be locked or sealed in the open position.

7.2.4.9 Antiflooding Device.

7.2.4.9.1 Unless the requirements of 7.2.4.9.2 are met, a listed antiflooding device shall be installed in the connection between the dry pipe sprinkler riser and the quick-opening device.

7.2.4.9.2 A listed antiflooding device shall not be required where the quick-opening device has built-in antiflooding design features.

7.2.5* Location and Protection of Dry Pipe Valve.

7.2.5.1* General. The dry pipe valve and supply pipe shall be protected against freezing and mechanical injury.

7.2.5.2 Valve Rooms.

7.2.5.2.1 Valve rooms shall be lighted and heated.

7.2.5.2.2 The source of heat shall be of a permanently installed type.

7.2.5.2.3 Heat tape shall not be used in lieu of heated valve enclosures to protect the dry pipe valve and supply pipe against freezing.

7.2.5.3 Supply. The supply for the sprinkler in the dry pipe valve enclosure shall be from the dry side of the system.

7.2.5.4 Low Differential Dry Pipe Valve. Protection against accumulation of water above the clapper shall be provided for a low differential dry pipe valve.

7.2.5.5 High Water Level Device. An automatic high water level signaling device or an automatic drain device shall be permitted.

7.2.6 Air Pressure and Supply.

7.2.6.1 Maintenance of Air Pressure. Air or nitrogen pressure shall be maintained on dry pipe systems throughout the year.

7.2.6.2* Air Supply.

7.2.6.2.1 The compressed air supply shall be from a source available at all times.

7.2.6.2.2 The air supply shall have a capacity capable of restoring normal air pressure in the system within 30 minutes.

7.2.6.2.3 The requirements of 7.2.6.2.2 shall not apply in refrigerated spaces maintained below 5°F (–15°C), where normal system air pressure shall be permitted to be restored within 60 minutes.

7.2.6.3 Air Filling Connection.

7.2.6.3.1 The connection pipe from the air compressor shall not be less than ½ in. (13 mm) in diameter and shall enter the system above the priming water level of the dry pipe valve.

7.2.6.3.2 A check valve shall be installed in this air line, and a shutoff valve of the renewable disc type shall be installed on the supply side of this check valve and shall remain closed unless filling the system.

7.2.6.4 Relief Valve. A listed relief valve shall be provided between the compressor and controlling valve and shall be set to relieve at a pressure 10 psi (0.7 bar) in excess of the operating air pressure of the system.

7.2.6.5 Shop Air Supply. Where the air supply is taken from a shop system having a normal pressure greater than that required for dry pipe system, an air maintenance device (regulator style) shall be used to regulate air pressure and flow to the system. A relief valve shall be installed between the outlet of the air maintenance device and dry system and set to relieve at 20 psi (0.7 bar) above the dry pipe system operating setpoint. *(See Figure 7.2.6.5.)*

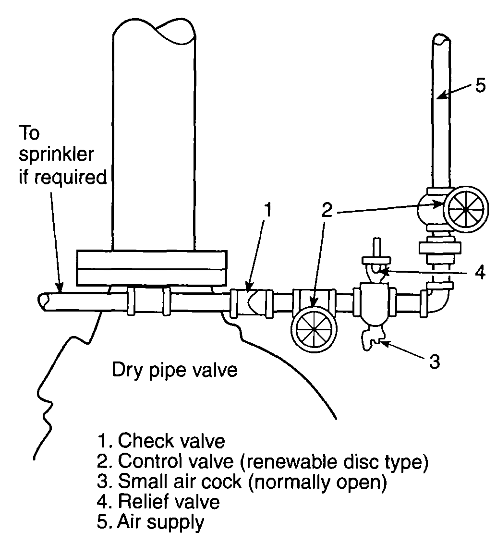


FIGURE 7.2.6.5 Air Supply from Shop System.

7.2.6.6 Automatic Air Compressor.

7.2.6.6.1 Where a dry pipe system is supplied by an automatic air compressor or plant air system, any device or apparatus used for automatic maintenance of air pressure shall be of a type specifically listed for such service and capable of controlling the required air pressure on, and maximum airflow to, the dry pipe system.

7.2.6.6.2 Automatic air supply to more than one dry pipe system shall be connected to enable individual maintenance of air pressure in each system.

7.2.6.6.3 A check valve or other positive backflow prevention device shall be installed in the air supply to each system to prevent airflow or waterflow from one system to another.

7.2.6.6.4 Where the air compressor feeding the dry pipe system has less capacity than the discharge through a ⅛-in. orifice at 10 psig, no air maintenance device shall be required.

7.2.6.7 System Air Pressure.

7.2.6.7.1 The system air pressure shall be maintained in accordance with the instruction sheet furnished with the dry pipe valve, or shall be 20 psi (1.4 bar) in excess of the calculated trip pressure of the dry pipe valve, based on the highest normal water pressure of the system supply.

7.2.6.7.2 The permitted rate of air leakage shall be as specified in 16.2.2.

7.2.6.8 Nitrogen. Where used, nitrogen shall be introduced through a pressure regulator set to maintain system pressure in accordance with 7.2.6.7.

7.3 Preaction Systems and Deluge Systems.

7.3.1* General.

7.3.1.1 All components of pneumatic, hydraulic, or electrical systems shall be compatible.

7.3.1.2 The automatic water control valve shall be provided with hydraulic, pneumatic, or mechanical manual means for operation that is independent of detection devices and of the sprinklers.

7.3.1.3 Pressure Gauges. Listed pressure gauges conforming with 8.16.3 shall be installed as follows:

(1) Above and below preaction valve and below deluge valve
(2) On air supply to preaction and deluge valves

7.3.1.4 A supply of spare fusible elements for heat-responsive devices, not less than two of each temperature rating, shall be maintained on the premises for replacement purposes.

7.3.1.5 Hydraulic release systems shall be designed and installed in accordance with manufacturer's requirements and listing for height limitations above deluge valves or deluge valve actuators to prevent water column.

7.3.1.6 Location and Spacing of Detection Devices. Spacing of detection devices, including automatic sprinklers used as detectors, shall be in accordance with their listing and manufacturer's specifications.

7.3.1.7 Devices for Test Purposes and Testing Apparatus.

7.3.1.7.1 Where detection devices installed in circuits are located where not readily accessible for testing, an additional detection device shall be provided on each circuit for test purposes at an accessible location and shall be connected to the circuit at a point that will assure a proper test of the circuit.

7.3.1.7.2 Testing apparatus capable of producing the heat or impulse necessary to operate any normal detection device shall be furnished to the owner of the property with each installation.

7.3.1.7.3 Where explosive vapors or materials are present, hot water, steam, or other methods of testing not involving an ignition source shall be used.

7.3.1.8 Location and Protection of System Water Control Valves.

7.3.1.8.1 System water control valves and supply pipes shall be protected against freezing and mechanical injury.

7.3.1.8.2 Valve Rooms.

7.3.1.8.2.1 Valve rooms shall be lighted and heated.

7.3.1.8.2.2 The source of heat shall be of a permanently installed type.

7.3.1.8.2.3 Heat tape shall not be used in lieu of heated valve enclosure rooms to protect preaction and deluge valves and supply pipe against freezing.

7.3.2 Preaction Systems.

7.3.2.1 Preaction systems shall be one of the following types:

(1) A single interlock system, which admits water to sprinkler piping upon operation of detection devices
(2) A non-interlock system, which admits water to sprinkler piping upon operation of detection devices or automatic sprinklers
(3) A double interlock system, which admits water to sprinkler piping upon operation of both detection devices and automatic sprinklers

7.3.2.2 Size of Systems.

7.3.2.2.1 Not more than 1000 automatic sprinklers shall be controlled by any one preaction valve.

7.3.2.2.2 Unless the requirements of 7.3.2.2.3 are met, for preaction system types described in 7.3.2.1(3), not more than 750 gal (2839 L) shall be controlled by one preaction valve.

7.3.2.2.3 The system volume for preaction system types described in 7.3.2.1(3) shall be permitted to exceed 750 gal (2839 L) where the system is designed to deliver water to the system test connection in not more than 60 seconds, starting at the normal air pressure on the system, with the detection system operated and at the time of fully opened inspection test connection. Air pressure and supply shall comply with 7.2.6.

7.3.2.3* Supervision.

7.3.2.3.1 Sprinkler piping and fire detection devices shall be automatically supervised where there are more than 20 sprinklers on the system.

7.3.2.3.2 All preaction system types described in 7.3.2.1(2) and 7.3.2.1(3) shall maintain a minimum supervising air pressure of 7 psi (0.5 bar).

7.3.2.4 Sprinklers. The following types of sprinklers and arrangements shall be permitted for preaction systems:

(1) Upright sprinklers
(2)*Listed dry sprinklers
(3) Pendent sprinklers and sidewall sprinklers installed on return bends, where the sprinklers, return bend, and branch line piping are in an area maintained at or above 40°F (4°C)
(4) Horizontal sidewall sprinklers, installed so that water is not trapped

7.3.2.5 System Configuration. Preaction systems of the type described in 7.3.2.1(3) shall not be gridded.

7.3.3* Deluge Systems.

7.3.3.1 The detection devices or systems shall be automatically supervised.

7.3.3.2 Deluge systems shall be hydraulically calculated.

7.4 Combined Dry Pipe and Preaction Systems.

7.4.1* General.

7.4.1.1* Combined automatic dry pipe and preaction systems shall be so constructed that failure of the detection system

shall not prevent the system from functioning as a conventional automatic dry pipe system.

7.4.1.2 Combined automatic dry pipe and preaction systems shall be so constructed that failure of the dry pipe system of automatic sprinklers shall not prevent the detection system from properly functioning as an automatic fire alarm system.

7.4.1.3 Provisions shall be made for the manual operation of the detection system at locations requiring not more than 200 ft (61 m) of travel.

7.4.1.4 Sprinklers. The following types of sprinklers and arrangements shall be permitted for combined dry pipe and preaction systems:

(1) Upright sprinklers
(2)*Listed dry sprinklers
(3) Pendent sprinklers and sidewall sprinklers installed on return bends, where both the sprinklers and the return bends are located in a heated area
(4) Horizontal sidewall sprinklers, installed so that water is not trapped

7.4.2 Dry Pipe Valves in Combined Systems.

7.4.2.1 Where the system consists of more than 600 sprinklers or has more than 275 sprinklers in any fire area, the entire system shall be controlled through two 6-in. (152-mm) dry pipe valves connected in parallel and shall feed into a common feed main.

7.4.2.2 Where parallel dry pipe valves are required by 7.4.2.1 these valves shall be checked against each other. *(See Figure 7.4.2.2.)*

7.4.2.3 Each dry pipe valve shall be provided with a listed tripping device actuated by the detection system.

7.4.2.4 Dry pipe valves shall be cross-connected through a 1-in. (25.4-mm) pipe connection to permit simultaneous tripping of both dry pipe valves.

7.4.2.5 The 1-in. (25.4-mm) cross-connection pipe shall be equipped with an indicating valve so that either dry pipe valve can be shut off and worked on while the other remains in service.

7.4.2.6 The check valves between the dry pipe valves and the common feed main shall be equipped with ½-in. (13-mm) bypasses so that a loss of air from leakage in the trimmings of a dry pipe valve will not cause the valve to trip until the pressure in the feed main is reduced to the tripping point.

7.4.2.7 An indicating valve shall be installed in each of these bypasses so that either dry pipe valve can be completely isolated from the main riser or feed main and from the other dry pipe valve.

7.4.2.8 Each combined dry pipe and preaction system shall be provided with listed quick-opening devices at the dry pipe valves.

7.4.3* Exhausters.

7.4.3.1 One or more listed exhausters of 2-in. (51-mm) or larger size controlled by operation of a fire detection system shall be installed at the end of the common feed main.

7.4.3.2 These air exhaust valves shall have soft-seated globe or angle valves in their intakes.

7.4.3.3 Approved strainers shall be installed between the globe valves and the air exhaust valves.

7.4.4 Subdivision of System Using Check Valves.

7.4.4.1 Where more than 275 sprinklers are required in a single fire area, the system shall be divided into sections of 275 sprinklers or fewer by means of check valves.

7.4.4.2 Where the system is installed in more than one fire area or story, not more than 600 sprinklers shall be supplied through any one check valve.

7.4.4.3 Each section shall have a 1¼-in. (33-mm) drain on the system side of each check valve supplemented by a dry pipe system auxiliary drain.

7.4.4.4 Section drain lines and dry pipe system auxiliary drains shall be located in heated areas or inside heated cabinets to enclose drain valves and auxiliary drains for each section.

7.4.4.5 Air exhaust valves at the end of a feed main and associated check valves shall be protected against freezing.

7.4.5 Time Limitation.

7.4.5.1 The sprinkler system shall be so constructed and the number of sprinklers controlled shall be so limited that water shall reach the farthest sprinkler within a period of time not exceeding 1 minute for each 400 ft (122 m) of common feed main from the time the heat-responsive system operates.

7.4.5.2 The maximum time permitted shall not exceed 3 minutes.

7.4.6 System Test Connection. The end section shall have a system test connection as required for dry pipe systems.

7.5 Antifreeze Systems.

7.5.1 General.

7.5.1.1 The use of antifreeze solutions shall be in conformity with state and local health regulations.

7.5.1.2 Antifreeze used in ESFR systems shall be specifically listed for ESFR applications.

7.5.2* Antifreeze Solutions.

7.5.2.1 Where sprinkler systems are supplied by potable water connections, the use of antifreeze solutions other than water solutions of pure glycerine (C.P. or U.S.P. 96.5 percent grade) or propylene glycol shall not be permitted.

7.5.2.2 Glycerine-water and propylene glycol–water mixtures shown in Table 7.5.2.2 shall be considered suitable for use.

7.5.2.3 If potable water is not connected to sprinklers, the commercially available materials indicated in Table 7.5.2.3 shall be permitted for use in antifreeze solutions.

7.5.2.4* An antifreeze solution shall be prepared with a freezing point below the expected minimum temperature for the locality.

7.5.2.5 The specific gravity of the prepared solution shall be checked by a hydrometer, in accordance with Figure 7.5.2.5(a), Figure 7.5.2.5(b), and Figure 7.5.2.5(c), with suitable scale or a refractometer having a scale calibrated for the antifreeze solution involved.

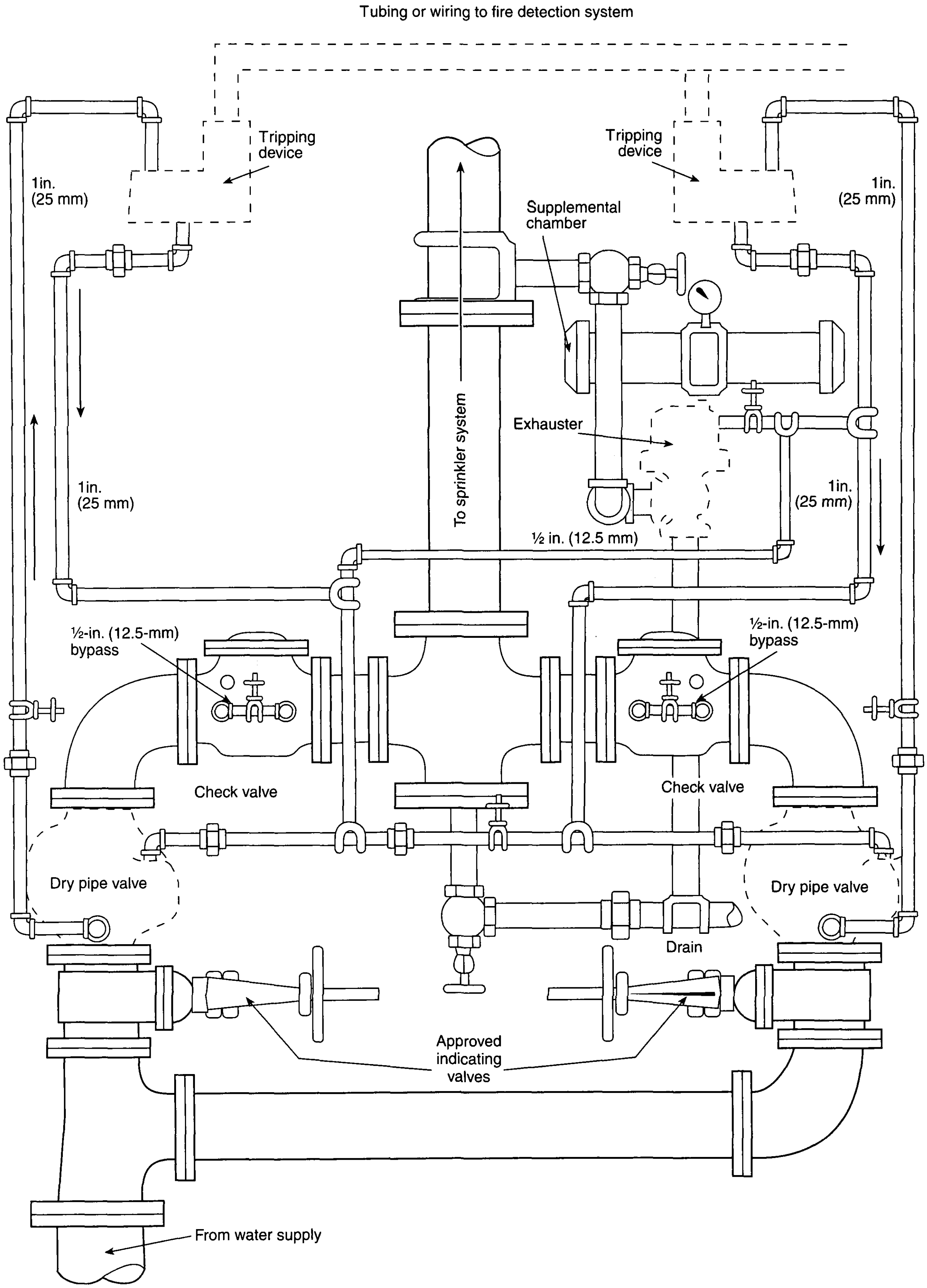


FIGURE 7.4.2.2 Header for Dry Pipe Valves Installed in Parallel for Combined Systems; Standard Trimmings Not Shown. Arrows Indicate Direction of Fluid Flow.

Table 7.5.2.2 Antifreeze Solutions to Be Used if Potable Water Is Connected to Sprinklers

Material	Solution (by volume)	Specific Gravity at 60°F (15.6°C)	Freezing Point °F	Freezing Point °C
Glycerine	50% water	1.145	−20.9	−29.4
C.P. or U.S.P. grade*	40% water	1.171	−47.3	−44.1
	30% water	1.197	−22.2	−30.1
Hydrometer scale 1.000 to 1.200				
Propylene glycol	70% water	1.027	+9	−12.8
	60% water	1.034	−6	−21.1
	50% water	1.041	−26	−32.2
	40% water	1.045	−60	−51.1
Hydrometer scale 1.000 to 1.200 (subdivisions 0.002)				

*C.P. — chemically pure; U.S.P. — United States Pharmacopoeia 96.5%.

Table 7.5.2.3 Antifreeze Solution to Be Used if Nonpotable Water Is Connected to Sprinklers

Material	Solution (by volume)	Specific Gravity at 60°F (15.6°C)	Freezing Point °F	Freezing Point °C
Glycerine	See Table 7.5.2.2.			
Diethylene glycol	50% water	1.078	−13	−25.0
	45% water	1.081	−27	−32.8
	40% water	1.086	−42	−41.1
Hydrometer scale 1.000 to 1.120 (subdivisions 0.002)				
Ethylene glycol	61% water	1.056	−10	−23.3
	56% water	1.063	−20	−28.9
	51% water	1.069	−30	−34.4
	47% water	1.073	−40	−40.0
Hydrometer scale 1.000 to 1.120 (subdivisions 0.002)				
Propylene glycol	See Table 7.5.2.2.			

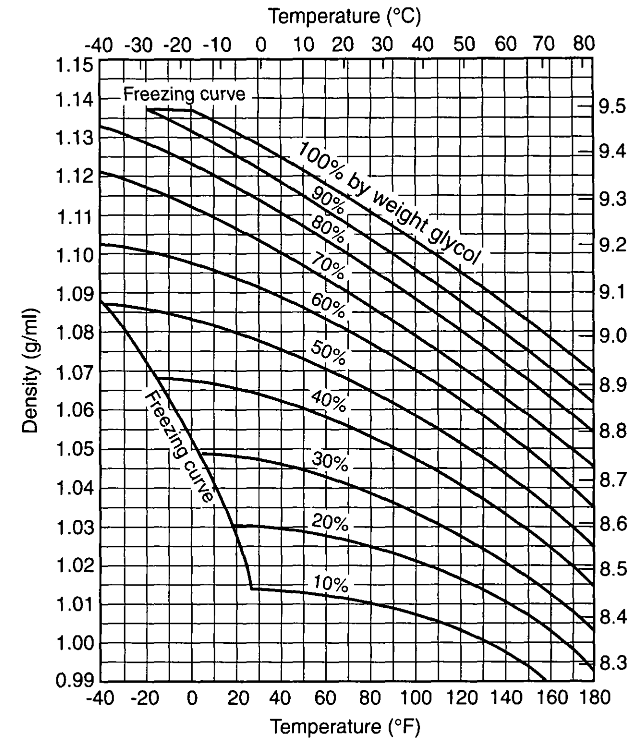


FIGURE 7.5.2.5(a) Densities of Aqueous Ethylene Glycol Solutions (Percent by Weight).

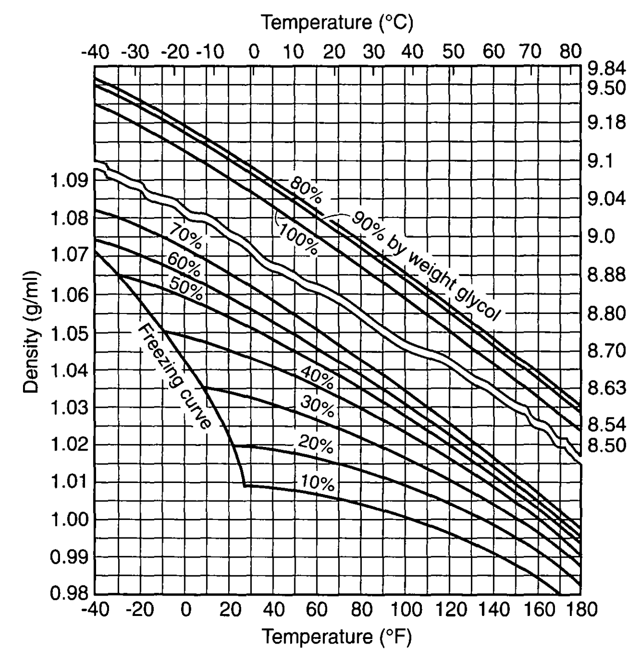
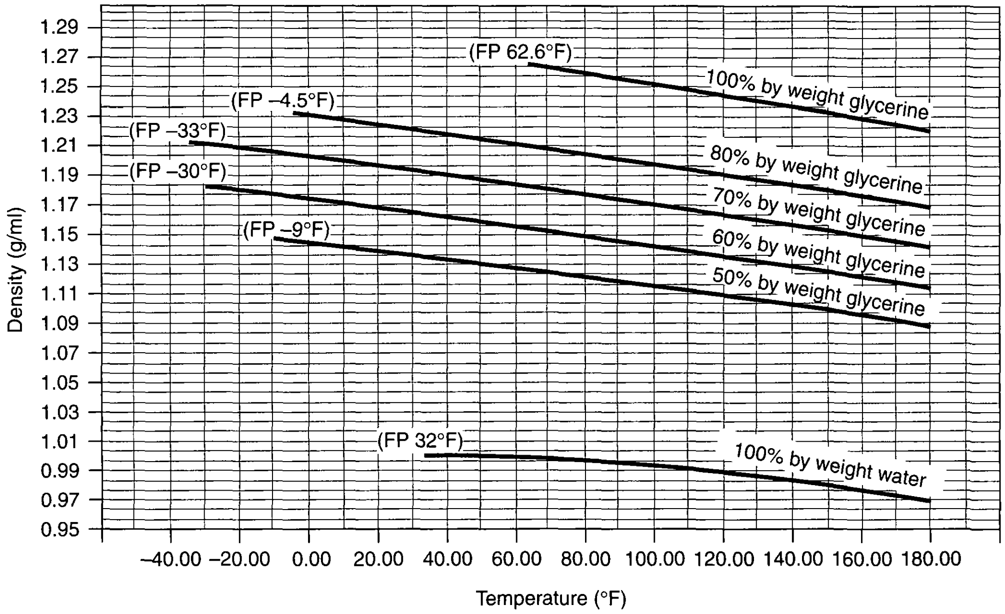


FIGURE 7.5.2.5(b) Densities of Aqueous Propylene Glycol Solutions (Percent by Weight).



Data Sources:

1. Density data for 100% water was taken from Lange's *Handbook of Chemistry*, Revised Tenth Edition, page 1199. Temperatures have been converted from Celsius to Fahrenheit units, and data points at 10 degree Fahrenheit multiples have been determined by linear interpolation. Conversion from relative to absolute density was achieved by multiplying by 0.999973.

2. Densities of glycerine-water solutions at 0°C and above were taken from Table III (p. 6) in *Glycerol* by Anthony Armin Newman, C.R.C. Press, 1968. Densities for temperatures below 0°C were taken from Table IV. Temperatures have been converted from Celsius to Fahrenheit units, and data points at 10 degree Fahrenheit multiples have been determined by linear interpolation.

3. Density data for pure glycerine was taken from Table II (p. 6) in *Glycerol* by Anthony Armin Newman, C.R.C. Press, 1968, and derived from the thermal expansion data in Table 7-9 in *Gycerol* by Carl S. Miner and N.N. Dalton, Reinhold Publishing Corp., 1953 (American Chemical Society Monograph Series #117) using the density for 0°C as a base point. Temperatures have been converted from Celsius to Fahrenheit units, and data points at 10 degree Fahrenheit multiples have been determined by linear interpolation.

4. Freezing points were taken from the article, "Freezing Points of Glycerol and Its Aqueous Solution" by Leonard B. Lane in *Industrial and Engineering Chemistry*, volume 17 (1925), number 9, page 924. Temperatures have been converted from Celsius to Fahrenheit units.

FIGURE 7.5.2.5(c) Densities of Aqueous Glycerine Solutions (Percent by Weight).

7.5.3 Arrangement of Supply Piping and Valves.

7.5.3.1* Where the connection between the antifreeze system and the wet pipe system does not incorporate a backflow prevention device, piping and valves shall be installed as illustrated in Figure 7.5.3.1.

7.5.3.2* Where the connection between the antifreeze system and the wet pipe system incorporates a backflow prevention device, piping and valves shall be installed as illustrated in Figure 7.5.3.2.

7.5.3.3 Where the connection between the antifreeze solution and the wet pipe system incorporates a backflow prevention device, a listed expansion chamber of appropriate size and precharged air pressure shall be provided to compensate for thermal expansion of the antifreeze solution as illustrated in Figure 7.5.3.2.

7.6 Automatic Sprinkler Systems with Non–Fire Protection Connections.

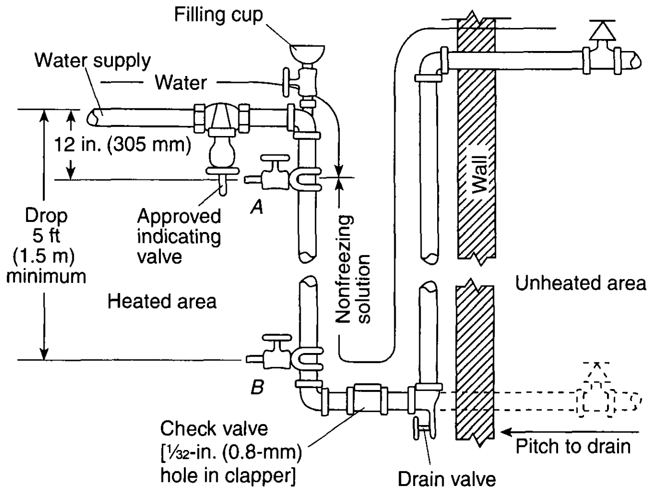
7.6.1 Circulating Closed-Loop Systems.

7.6.1.1 System Components.

7.6.1.1.1 A circulating closed-loop system is primarily a sprinkler system and shall comply with all provisions of this standard such as those for control valves, area limitations of a system, alarms, fire department connections, sprinkler spacing, and so forth except as modified by Section 7.6.

7.6.1.1.2 Piping, fittings, valves, and pipe hangers shall meet the requirements specified in Chapter 6.

7.6.1.1.3 Unless the requirements of 7.6.1.1.4 are met, a dielectric fitting shall be installed in the junction where dissimilar piping materials are joined (e.g., copper to steel).



Notes:
1. Check valve shall be permitted to be omitted where sprinklers are below the level of valve *A*.
2. The 1/32-in. (0.8-mm) hole in the check valve clapper is needed to allow for expansion of the solution during a temperature rise, thus preventing damage to sprinklers.

FIGURE 7.5.3.1 Arrangement of Supply Piping and Valves.

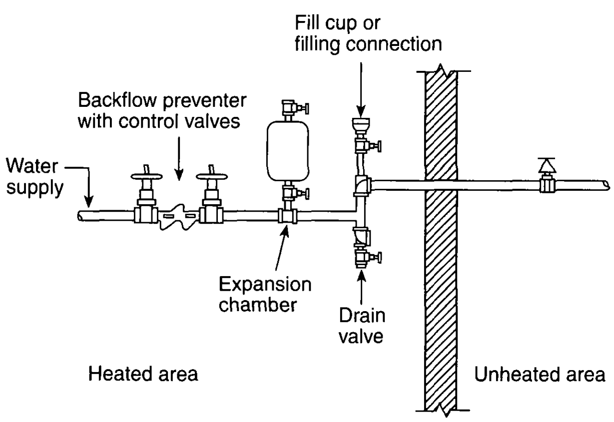


FIGURE 7.5.3.2 Arrangement of Supply Piping with Backflow Device.

7.6.1.1.4 Dielectric fittings shall not be required in the junction where sprinklers are connected to piping.

7.6.1.1.5 Other auxiliary devices shall not be required to be listed for sprinkler service; however, these devices, such as pumps, circulating pumps, heat exchangers, radiators, and luminaries, shall be pressure rated at 175 psi or 300 psi (12.1 bar or 20.7 bar) (rupture pressure of five times rated water system working pressure) to match the required rating of sprinkler system components.

7.6.1.1.6 Auxiliary devices shall incorporate materials of construction and be so constructed that they will maintain their physical integrity under fire conditions to avoid impairment to the fire protection system.

7.6.1.1.7 Auxiliary devices, where hung from the building structure, shall be supported independently from the sprinkler portion of the system, following recognized engineering practices.

7.6.1.2* Hydraulic Characteristics. Piping systems for attached heating and cooling equipment shall have auxiliary pumps or an arrangement made to return water to the piping system in order to assure the following:

(1) Water for sprinklers shall not be required to pass through heating or cooling equipment.
(2) At least one direct path shall exist for waterflow from the sprinkler water supply to every sprinkler.
(3) Pipe sizing in the direct path shall be in accordance with the design requirements of this standard.
(4) No portions of the sprinkler piping shall have less than the sprinkler system design pressure, regardless of the mode of operation of the attached heating or cooling equipment.
(5) There shall be no loss or outflow of water from the system due to or resulting from the operation of heating or cooling equipment.
(6) Shutoff valves and a means of drainage shall be provided on piping to heating or cooling equipment at all points of connection to sprinkler piping and shall be installed in such a manner as to make possible repair or removal of any auxiliary component without impairing the serviceability and response to the sprinkler system.
(7) All auxiliary components, including the strainer, shall be installed on the auxiliary equipment side of the shutoff valves.

7.6.1.3 Water Temperature.

7.6.1.3.1 Maximum.

7.6.1.3.1.1 In no case shall maximum water temperature flowing through the sprinkler portion of the system exceed 120°F (49°C).

7.6.1.3.1.2 Protective control devices listed for this purpose shall be installed to shut down heating or cooling systems when the temperature of water flowing through the sprinkler portion of the system exceeds 120°F (49°C).

7.6.1.3.1.3 Where the water temperature exceeds 100°F (37.8°C), intermediate or higher temperature–rated sprinklers shall be used.

7.6.1.3.2 Minimum. Precautions shall be taken to ensure that temperatures below 40°F (4°C) are not permitted.

7.6.1.4 Obstruction to Discharge. Automatic sprinklers shall not be obstructed by auxiliary devices, piping, insulation, and so forth, from detecting fire or from proper distribution of water.

7.6.1.5 Signs. Caution signs shall be attached to all valves controlling sprinklers. The caution sign shall be worded as follows:

This valve controls fire protection equipment. Do not close until after fire has been extinguished. Use auxiliary valves when necessary to shut off supply to auxiliary equipment.

CAUTION: Automatic alarm will be sounded if this valve is closed.

7.6.1.6 Water Additives.

7.6.1.6.1 Materials added to water shall not adversely affect the fire-fighting properties of the water and shall be in conformity with any state or local health regulations.

7.6.1.6.2 Due care and caution shall be given to the use of additives that can remove or suspend scale from older piping systems.

7.6.1.6.3 Where additives are necessary for proper system operation, due care shall be taken to ensure that additives are replenished after alarm testing or whenever water is removed from the system.

7.6.1.7 Waterflow Detection.

7.6.1.7.1 The supply of water from sprinkler piping through auxiliary devices, circulatory piping, and pumps shall not under any condition or operation, transient or static, cause false sprinkler waterflow signals.

7.6.1.7.2 A sprinkler waterflow signal shall not be impaired when water is discharged through an opened sprinkler or through the system test connection while auxiliary equipment is in any mode of operation (on, off, transient, stable).

7.7 Outside Sprinklers for Protection Against Exposure Fires.

7.7.1 Applications. Exposure protection systems shall be permitted on buildings regardless of whether the building's interior is protected by a sprinkler system.

7.7.2 Water Supply and Control.

7.7.2.1* Unless the requirements of 7.7.2.2 are met, sprinklers installed for protection against exposure fires shall be supplied from a standard water supply as outlined in Chapter 15.

7.7.2.2 Where approved, other supplies, such as manual valves or pumps or fire department connections, shall be permitted to supply water to sprinklers for exposure protection.

7.7.2.3 Where fire department connections are used for water supply, they shall be so located that they will not be affected by the exposing fire.

7.7.3 Control.

7.7.3.1 Each system of outside sprinklers shall have an independent control valve.

7.7.3.2 Manually controlled open sprinklers shall be used only where constant supervision is present.

7.7.3.3 Sprinklers shall be of the open or automatic type. Automatic sprinklers in areas subject to freezing shall be on dry pipe systems conforming to Section 7.2 or antifreeze systems conforming to Section 7.5.

7.7.3.4 Automatic systems of open sprinklers shall be controlled by the operation of fire detection devices designed for the specific application.

7.7.4 System Components.

7.7.4.1 Drain Valves. Each system of outside sprinklers shall have a separate drain valve installed on the system side of each control valve, except where an open sprinkler, top-fed system is arranged to facilitate drainage.

7.7.4.2 Check Valves.

7.7.4.2.1 Where sprinklers are installed on two adjacent sides of a building, protecting against two separate and distinct exposures, with separate control valves for each side, the end lines shall be connected with check valves located so that one sprinkler around the corner will operate *[see Figure 7.7.4.2.1(a) and Figure 7.7.4.2.1(b)]*.

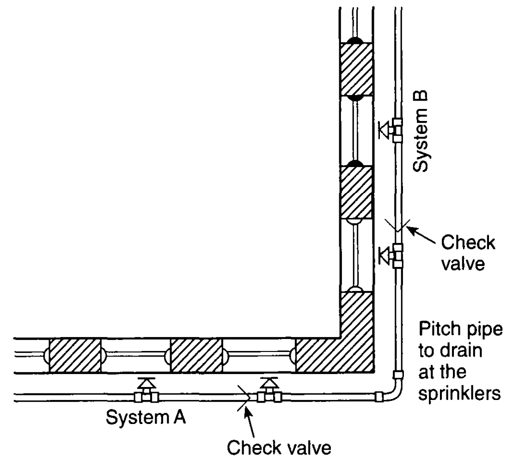


FIGURE 7.7.4.2.1(a) Typical Arrangement of Check Valves.

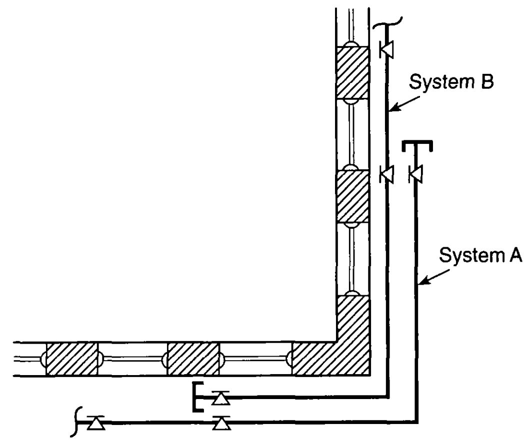


FIGURE 7.7.4.2.1(b) Alternate Arrangement of Check Valves.

7.7.4.2.2 The intermediate pipe between the two check valves shall be arranged to drain.

7.7.4.2.3 As an alternate solution, an additional sprinkler shall be installed on each system located around the corner from the system involved.

7.7.4.3 System Arrangement. Where one exposure affects two sides of the protected structure, the system shall not be subdivided between the two sides but rather shall be arranged to operate as a single system.

7.7.5 Pipe and Fittings. Pipe and fittings installed on the exterior of the building shall be corrosion resistant.

7.7.6 Strainers. A listed strainer shall be provided in the riser or feed main that supplies sprinklers having nominal K-factors smaller than 2.8 (4.0).

7.7.7 Gauge Connections. A listed pressure gauge conforming with 8.16.3 shall be installed immediately below the control valve of each system.

7.7.8 Sprinklers.

7.7.8.1 Only sprinklers of such type as are listed for window, cornice, sidewall, or ridge pole service shall be in-

stalled for such use, except where adequate coverage by use of other types of listed sprinklers and/or nozzles has been demonstrated.

7.7.8.2 Small-orifice or large-orifice sprinklers shall be permitted.

7.8* Refrigerated Spaces.

7.8.1 Spaces Maintained at Temperatures Above 32°F (0°C). Where temperatures are maintained above 32°F (0°C) in refrigerated spaces, the requirements in this section shall not apply.

7.8.2* Spaces Maintained at Temperatures Below 32°F (0°C).

7.8.2.1 General.

7.8.2.1.1 Where sprinkler pipe passes through a wall or floor into the refrigerated space, a section of pipe arranged for removal shall be provided immediately inside the space.

7.8.2.1.2 The removable length of pipe required in 7.8.2.1.1 shall be a minimum of 30 in. (762 mm).

7.8.2.2 Low Air Pressure Alarm.

7.8.2.2.1 Unless the requirements of 7.8.2.2.2 are met, a low air pressure alarm to a constantly attended location shall be installed.

7.8.2.2.2 Systems equipped with local low pressure alarms and an automatic air maintenance device shall not be required to alarm to a constantly attended location.

7.8.2.3 Piping Pitch. Piping in refrigerated spaces shall be installed with pitch as outlined in 8.15.2.3.

7.8.2.4* Air or Nitrogen Supply. Air or nitrogen supply for systems shall be one of the following:

(1) Air from the room of lowest temperature to reduce the moisture content
(2) Air compressor/dryer package listed for the application utilizing ambient air
(3) Compressed nitrogen gas from cylinders used in lieu of compressed air

7.8.2.5* Control Valve. An indicating-type control valve for operational testing of the system shall be provided on each sprinkler riser outside of the refrigerated space.

7.8.2.6* Check Valve.

7.8.2.6.1 Unless the requirements of 7.8.2.6.2 are met, a check valve with a 3⁄32-in. (2.4-mm) diameter hole in the clapper shall be installed in the system riser below the test valve required in 7.8.2.5.

7.8.2.6.2 Check valves shall not be required where dry pipe or preaction valves are used and designed to completely drain all water above the seat and that are listed for installation without priming water remaining and where priming water is not used in the system riser.

7.8.2.7* Air or Nitrogen Supply Piping.

7.8.2.7.1 The air or nitrogen supply piping entering the freezer area shall be as stated in 7.8.2.7.1.1 and 7.8.2.7.1.2.

7.8.2.7.1.1 Air Supply. The supply piping shall be equipped with two easily removable supply lines at least 6 ft (1.9 m) long and at least 1 in. (25.4 mm) in diameter as shown in Figure 7.8.2.7.1.1.

7.8.2.7.1.2 Nitrogen Supply. The supply piping shall be equipped with a single easily removable supply line at least 6 ft (1.9 m) long and at least 1 in. (25.4 mm) in diameter.

7.8.2.7.2 Each supply line shall be equipped with control valves located in the warm area.

7.8.2.7.3 Only one air supply line shall be open to supply the system air at any one time.

7.9 Commercial-Type Cooking Equipment and Ventilation.

7.9.1 General. In cooking areas protected by automatic sprinklers, additional sprinklers or automatic spray nozzles shall be provided to protect commercial-type cooking equipment and ventilation systems that are designed to carry away grease-laden vapors unless otherwise protected. *(See NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.)*

7.9.2* Sprinklers and Automatic Spray Nozzles.

7.9.2.1 Unless the requirements of 7.9.2.2 are met, standard sprinklers or automatic spray nozzles shall be so located as to provide for the protection of exhaust ducts, hood exhaust duct collars, and hood exhaust plenum chambers.

7.9.2.2 Sprinklers or automatic spray nozzles in ducts, duct collars, and plenum chambers shall not be required where all cooking equipment is served by listed grease extractors.

7.9.3 Sprinkler and Automatic Spray Nozzle Location — Ducts.

7.9.3.1 Unless the requirements of 7.9.3.2 or 7.9.3.4 are met, exhaust ducts shall have one sprinkler or automatic spray nozzle located at the top of each vertical riser and at the midpoint of each offset.

7.9.3.2 Sprinklers or automatic spray nozzles shall not be required in a vertical riser located outside of a building, provided the riser does not expose combustible material or provided the interior of the building and the horizontal distance between the hood outlet and the vertical riser is at least 25 ft (7.6 m).

7.9.3.3 Unless the requirements of 7.9.3.4 are met, horizontal exhaust ducts shall have sprinklers or automatic spray nozzle devices located on 10 ft (3 m) centers beginning no more than 5 ft (1.5 m) from the duct entrance.

7.9.3.4 Sprinklers or automatic spray nozzles shall not be required where the entire exhaust duct is connected to a listed exhaust hood incorporating a specific duct collar and sprinkler (or automatic spray nozzle) assembly that has been investigated and been shown to protect an unlimited length of duct in accordance with UL 300, *Standard for Safety Fire Testing of Fire Extinguishing Systems for Protection of Restaurant Cooking Areas.*

7.9.3.5 A sprinkler(s) or an automatic spray nozzle(s) in exhaust ducts subject to freezing shall be properly protected against freezing by approved means. *(See 8.15.3.1.)*

7.9.4 Sprinkler and Automatic Spray Nozzle Location — Duct Collar.

7.9.4.1 Each hood exhaust duct collar shall have one sprinkler or automatic spray nozzle located 1 in. minimum to 12 in. maximum (25.4 mm minimum to 305 mm maximum) above the point of duct collar connection in the hood plenum.

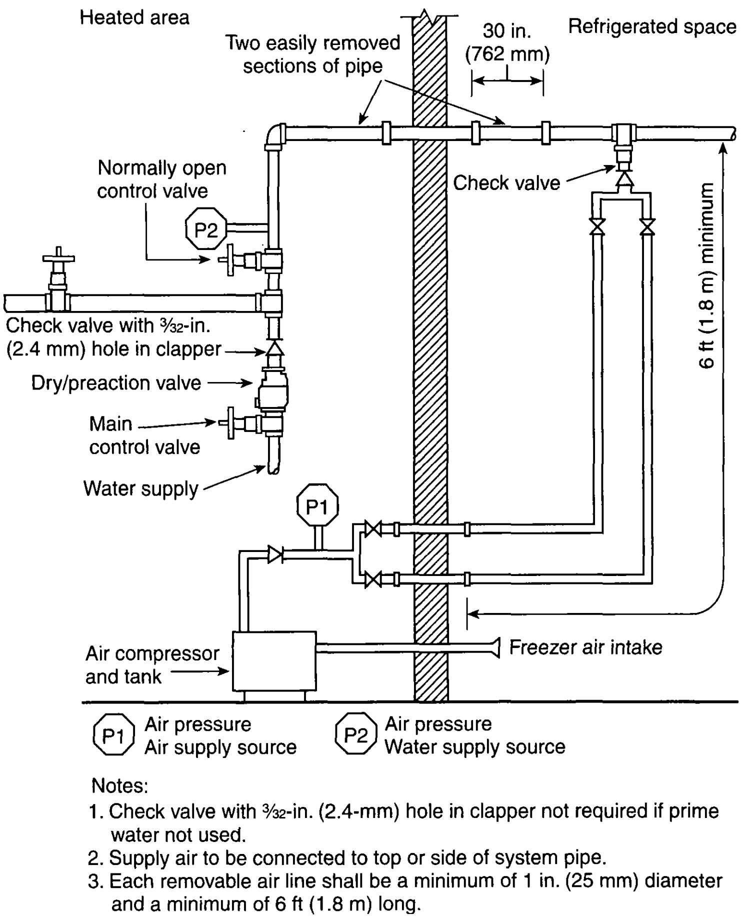


FIGURE 7.8.2.7.1.1 Refrigerator Area Sprinkler System Used to Minimize the Chances of Developing Ice Plugs.

7.9.4.2 Hoods that have listed fire dampers located in the duct collar shall be protected with a sprinkler or automatic spray nozzle located on the discharge side of the damper and shall be so positioned as not to interfere with damper operation.

7.9.5 Sprinkler and Automatic Spray Nozzle Location — Exhaust Plenum Chambers.

7.9.5.1 Hood exhaust plenum chambers shall have one sprinkler or automatic spray nozzle centered in each chamber not exceeding 10 ft (3 m) in length.

7.9.5.2 Plenum chambers greater than 10 ft (3 m) in length shall have two sprinklers or automatic spray nozzles evenly spaced, with the maximum distance between the two sprinklers not to exceed 10 ft (3 m).

7.9.6 Sprinkler and Automatic Spray Nozzle Temperature Ratings and Orifice Sizes.

7.9.6.1 Where the exposed temperature is expected to be 300°F (149°C) or less, sprinklers, or automatic spray nozzles being used in duct, duct collar, and plenum areas shall be of the extra high–temperature classification [325°F to 375°F (163°C to 191°C)].

7.9.6.2 When use of a temperature-measuring device indicates temperatures above 300°F (149°C), a sprinkler or automatic spray nozzle of higher classification shall be used.

7.9.6.3 Sprinklers or automatic spray nozzles being used in duct, duct collar, and plenum areas shall have orifice with K-factors not less than 1.4 and not more than 5.6.

7.9.7 Sprinkler and Automatic Spray Nozzle. Access shall be provided to all sprinklers or automatic spray nozzles for examination and replacement.

7.9.8 Cooking Equipment.

7.9.8.1 General. Cooking equipment (such as deep fat fryers, ranges, griddles, and broilers) that is considered to be a source of ignition shall be protected in accordance with the provisions of 7.9.1.

7.9.8.2 Listed Sprinkler and Automatic Spray Nozzles.

7.9.8.2.1 A sprinkler or automatic spray nozzle used for protection of deep fat fryers shall be listed for that application.

7.9.8.2.2 The position, arrangement, location, and water supply for each sprinkler or automatic spray nozzle shall be in accordance with its listing.

7.9.8.3 Fuel and Heat Shut Off.

7.9.8.3.1 The operation of any cooking equipment sprinkler or automatic spray nozzle shall automatically shut off all sources of fuel and heat to all equipment requiring protection.

7.9.8.3.2 Any gas appliance not requiring protection but located under ventilating equipment shall also be shut off.

7.9.8.3.3 All shutdown devices shall be of the type that requires manual resetting prior to fuel or power being restored.

7.9.9 Indicating Valves. A listed indicating valve shall be installed in the water supply line to the sprinklers and spray nozzles protecting the cooking and ventilating system.

7.9.10 Strainers. A listed line strainer shall be installed in the main water supply preceding sprinklers or automatic spray nozzles having nominal K-factors smaller than 2.8 (4.0).

7.9.11 Test Connection. A system test connection shall be provided to verify proper operation of equipment specified in 7.9.8.3.

7.9.12 Sprinkler and Automatic Spray Nozzle Replacement.

7.9.12.1 Unless the requirements of 7.9.12.2 are met, sprinklers and automatic spray nozzles used for protecting commercial-type cooking equipment and ventilating systems shall be replaced annually.

7.9.12.2 Where automatic bulb-type sprinklers or spray nozzles are used and annual examination shows no buildup of grease or other material on the sprinklers or spray nozzles, such sprinklers or spray nozzles shall be permitted to be continued in use.

Chapter 8 Installation Requirements

8.1* Basic Requirements.

8.1.1* The requirements for spacing, location, and position of sprinklers shall be based on the following principles:

(1) Sprinklers shall be installed throughout the premises.
(2) Sprinklers shall be located so as not to exceed maximum protection area per sprinkler.
(3) Sprinklers shall be positioned and located so as to provide satisfactory performance with respect to activation time and distribution.
(4) Sprinklers shall be permitted to be omitted from areas specifically allowed by this standard.
(5) When sprinklers are specifically tested and test results demonstrate that deviations from clearance requirements to structural members do not impair the ability of the sprinkler to control or suppress a fire, their positioning and locating in accordance with the test results shall be permitted.
(6) Clearance between sprinklers and ceilings exceeding the maximums specified in this standard shall be permitted provided that tests or calculations demonstrate comparable sensitivity and performance of the sprinklers to those installed in conformance with these sections.

8.1.2* System valves and gauges shall be accessible for operation, inspection, tests, and maintenance.

8.2 System Protection Area Limitations.

8.2.1 The maximum floor area on any one floor to be protected by sprinklers supplied by any one sprinkler system riser or combined system riser shall be as follows:

(1) Light hazard — 52,000 ft^2 (4831 m^2)
(2) Ordinary hazard — 52,000 ft^2 (4831 m^2)
(3) Extra hazard
  (a) Pipe schedule — 25,000 ft^2 (2323 m^2)
  (b) Hydraulically calculated — 40,000 ft^2 (3716 m^2)
(4) Storage — High-piled storage (as defined in 3.3.12) and storage covered by other NFPA standards — 40,000 ft^2 (3716 m^2)

8.2.2 The floor area occupied by mezzanines shall not be included in the area limits of 8.2.1.

8.2.3 Where single systems protect extra hazard, high-piled storage, or storage covered by other NFPA standards, and ordinary or light hazard areas, the extra hazard or storage area coverage shall not exceed the floor area specified for that hazard and the total area coverage shall not exceed 52,000 ft^2 (4831 m^2).

8.3 Use of Sprinklers.

8.3.1 General.

8.3.1.1* Sprinklers shall be installed in accordance with their listing.

8.3.1.2 The requirements of 8.3.1.1 shall not apply where construction features or other special situations require unusual water distribution, and listed sprinklers shall be permitted to be installed in positions other than anticipated by their listing to achieve specific results.

8.3.1.3* Upright sprinklers shall be installed with the frame arms parallel to the branch line, unless specifically listed for other orientation.

8.3.1.4 Where solvent cement is used as the pipe and fittings bonding agent, sprinklers shall not be installed in the fittings prior to the fittings being cemented in place.

8.3.2 Temperature Ratings.

8.3.2.1* Unless the requirements of 8.3.2.2. 8.3.2.3, 8.3.2.4, or 8.3.2.5 are met, ordinary temperature–rated sprinklers shall be used throughout buildings.

8.3.2.2 Where maximum ceiling temperatures exceed 100°F (38°C), sprinklers with temperature ratings in accordance with the maximum ceiling temperatures of Table 6.2.5.1 shall be used.

8.3.2.3 Intermediate- and high-temperature sprinklers shall be permitted to be used throughout ordinary and extra hazard occupancies and as allowed in this standard and other NFPA codes and standards.

8.3.2.4 Sprinklers of intermediate- and high-temperature classifications shall be installed in specific locations as required by 8.3.2.5.

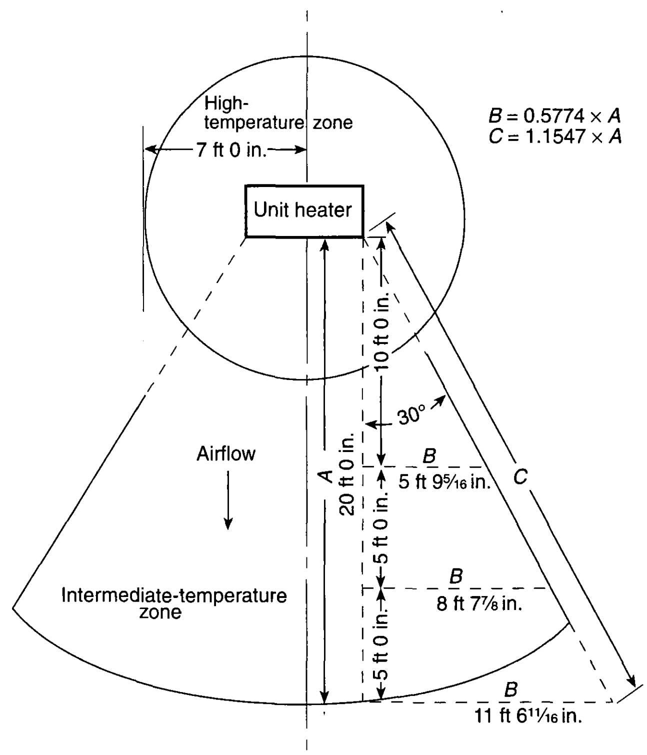
8.3.2.5 The following practices shall be observed to provide sprinklers of other than ordinary-temperature classification unless other temperatures are determined or unless high-temperature sprinklers are used throughout and temperature selection shall be in accordance with Table 8.3.2.5(a), Table 8.3.2.5(b), and Figure 8.3.2.5:

(1) Sprinklers in the high-temperature zone shall be of the high-temperature classification, and sprinklers in the intermediate-temperature zone shall be of the intermediate-temperature classification.

(2) Sprinklers located within 12 in. (305 mm) to one side or 30 in. (762 mm) above an uncovered steam main, heating coil, or radiator shall be of the intermediate-temperature classification.
(3) Sprinklers within 7 ft (2.1 m) of a low-pressure blowoff valve that discharges free in a large room shall be of the high-temperature classification.
(4) Sprinklers under glass or plastic skylights exposed to the direct rays of the sun shall be of the intermediate-temperature classification.
(5) Sprinklers in an unventilated, concealed space, under an uninsulated roof, or in an unventilated attic shall be of the intermediate-temperature classification.
(6) Sprinklers in unventilated show windows having high-powered electric lights near the ceiling shall be of the intermediate-temperature classification.
(7) Sprinklers protecting commercial-type cooking equipment and ventilation systems shall be of the high- or extra high–temperature classification as determined by use of a temperature-measuring device. *(See 7.9.6.)*
(8) Sprinklers protecting residential areas installed near specific heat sources identified in Table 8.3.2.5(c) shall be installed in accordance with Table 8.3.2.5(c).

8.3.2.6 In case of occupancy change involving temperature change, the sprinklers shall be changed accordingly.

8.3.2.7* The minimum temperature rating of ceiling sprinklers in general storage, rack storage, rubber tire storage, roll paper storage, and baled cotton storage applications shall be 150°F (66°C).



SI units: 1 in. = 25.4 mm; 1 ft = 0.31 m.

FIGURE 8.3.2.5 High-Temperature and Intermediate-Temperature Zones at Unit Heaters.

Table 8.3.2.5(a) Temperature Ratings of Sprinklers Based on Distance from Heat Sources

Type of Heat Condition	Ordinary Degree Rating	Intermediate Degree Rating	High Degree Rating
(1) Heating ducts			
(a) Above	More than 2 ft 6 in.	2 ft 6 in. or less	
(b) Side and below	More than 1 ft 0 in.	1 ft 0 in. or less	
(c) Diffuser	Any distance except as shown under Intermediate Degree Rating column	*Downward discharge:* Cylinder with 1 ft 0 in. radius from edge extending 1 ft 0 in. below and 2 ft 6 in. above *Horizontal discharge:* Semicylinder with 2 ft 6 in. radius in direction of flow extending 1 ft 0 in. below and 2 ft 6 in. above	
(2) Unit heater			
(a) Horizontal discharge		*Discharge side:* 7 ft 0 in. to 20 ft 0 in. radius pie-shaped cylinder *(see Figure 8.3.2.5)* extending 7 ft 0 in. above and 2 ft 0 in. below heater; also 7 ft 0 in. radius cylinder more than 7 ft 0 in. above unit heater	7 ft 0 in. radius cylinder extending 7 ft 0 in. above and 2 ft 0 in. below unit heater
(b) Vertical downward discharge *(for sprinklers below unit heater, see Figure 8.3.2.5)*		7 ft 0 in. radius cylinder extending upward from an elevation 7 ft 0 in. above unit heater	7 ft 0 in. radius cylinder extending from the top of the unit heater to an elevation 7 ft 0 in. above unit heater
(3) Steam mains (uncovered)			
(a) Above	More than 2 ft 6 in.	2 ft 6 in. or less	
(b) Side and below	More than 1 ft 0 in.	1 ft 0 in. or less	
(c) Blowoff valve	More than 7 ft 0 in.		7 ft 0 in. or less

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.

Table 8.3.2.5(b) Ratings of Sprinklers in Specified Locations

Location	Ordinary Degree Rating	Intermediate Degree Rating	High Degree Rating
Skylights		Glass or plastic	
Attics	Ventilated	Unventilated	
Peaked roof: metal or thin boards, concealed or not concealed, insulated or uninsulated	Ventilated	Unventilated	
Flat roof: metal, not concealed	Ventilated or unventilated	Note: For uninsulated roof, climate and insulated or uninsulated occupancy can necessitate intermediate sprinklers. Check on job.	
Flat roof: metal, concealed, insulated or uninsulated	Ventilated	Unventilated	
Show windows	Ventilated	Unventilated	

Note: A check of job condition by means of thermometers might be necessary.

Table 8.3.2.5(c) Ratings of Sprinklers in Specified Residential Areas

Heat Source	Minimum Distance from Edge of Source to Ordinary-Temperature Sprinkler in.	Minimum Distance from Edge of Source to Ordinary-Temperature Sprinkler mm	Minimum Distance from Edge of Source to Intermediate-Temperature Sprinkler in.	Minimum Distance from Edge of Source to Intermediate-Temperature Sprinkler mm
Side of open or recessed fireplace	36	914	12	305
Front of recessed fireplace	60	1524	36	914
Coal- or wood-burning stove	42	1067	12	305
Kitchen range	18	457	9	229
Wall oven	18	457	9	229
Hot air flues	18	457	9	229
Uninsulated heat ducts	18	457	9	229
Uninsulated hot water pipes	12	305	6	152
Side of ceiling- or wall-mounted hot air diffusers	24	607	12	305
Front of wall-mounted hot air diffusers	36	914	18	457
Hot water heater or furnace	6	152	3	76
Light fixture: 0 W–250 W	6	152	3	76
250 W–499 W	12	305	6	152

8.3.3 Thermal Sensitivity.

8.3.3.1* Sprinklers in light hazard occupancies shall be one of the following:

(1) Quick-response type as defined in 3.6.2.9
(2) Residential sprinklers in accordance with the requirements of 8.4.5
(3) Standard response sprinklers used for modifications or additions to existing light hazard systems equipped with standard response sprinklers
(4) Standard response sprinklers used where individual standard response sprinklers are replaced in existing light hazard systems

8.3.3.2 Where quick-response sprinklers are installed, all sprinklers within a compartment shall be of the quick-response type.

8.3.3.3 Where circumstances require the use of other than ordinary temperature–rated sprinklers, standard response sprinklers shall be permitted to be used.

8.3.3.4 When existing light hazard systems are converted to use quick-response or residential sprinklers, all sprinklers in a compartmented space shall be changed.

8.3.4 Small Orifice Sprinklers.

8.3.4.1 For light hazard occupancies not requiring as much water as is discharged by a sprinkler with a nominal K-factor of

5.6 operating at 7 psi (0.5 bar), sprinklers having a smaller orifice shall be permitted subject to the following restrictions:

(1) The system shall be hydraulically calculated.
(2) Sprinklers with K-factors of less than 5.6 shall be installed only in wet pipe sprinkler systems or in accordance with the limitations of 8.3.4.2.
(3) A listed strainer shall be provided on the supply side of sprinklers with nominal K-factors of less than 2.8.

8.3.4.2 Sprinklers with K-factors of less than 5.6 shall be permitted to be installed in conformance with 11.2.3.7 for protection against exposure fires.

8.3.5 Thread Size Limitations. Sprinklers having a K-factor exceeding 5.6 and having ½-in. (13-mm) National Pipe Thread (NPT) shall not be installed in new sprinkler systems.

8.4* Application of Sprinkler Types. Sprinklers shall be selected for use as indicated in this section and shall be positioned and spaced as described in Section 8.5.

8.4.1 Standard Upright and Pendent Spray Sprinklers.

8.4.1.1 Upright and pendent spray sprinklers shall be permitted in all occupancy hazard classifications and building construction types.

8.4.1.2 Quick-response sprinklers shall not be permitted for use in extra hazard occupancies under the density-area design method.

8.4.2 Sidewall Spray Sprinklers. Sidewall sprinklers shall only be installed as follows:

(1) Light hazard occupancies with smooth, horizontal or sloped, flat ceilings
(2) Ordinary hazard occupancies with smooth, flat ceilings where specifically listed for such use
(3) To protect areas below overhead doors

8.4.3 Extended Coverage Sprinklers. Extended coverage sprinklers shall only be installed as follows:

(1) Unobstructed construction consisting of flat, smooth ceilings with a slope not exceeding a pitch of one in six (a rise of two units in a run of 12 units, a roof slope of 16.7 percent)
(2) Unobstructed or noncombustible obstructed construction, where specifically listed for such use
(3) Within trusses or bar joists having web members not greater than 1 in. (25.4 mm) maximum dimension or where trusses are spaced greater than 7½ ft (2.3 m) on center and where the ceiling slope does not exceed a pitch of one in six (a rise of two units in a run of 12 units, a roof slope of 16.7 percent)
(4) Under smooth, flat ceilings that have slopes not exceeding a pitch of one in three (a rise of four units in a run of 12 units, a roof slope of 33.3 percent), where specifically listed for such use

8.4.4 Open Sprinklers.

8.4.4.1 Open sprinklers shall be permitted to be used in deluge systems to protect special hazards or exposures or in other special locations.

8.4.4.2 Open sprinklers shall be installed in accordance with all applicable requirements of this standard for their automatic counterpart.

8.4.5 Residential Sprinklers.

8.4.5.1* Residential sprinklers shall be permitted in dwelling units and their adjoining corridors provided they are installed in conformance with their listing.

8.4.5.2 Residential sprinklers shall be used only in wet systems unless specifically listed for use in dry systems or preaction systems.

8.4.5.3 Where residential sprinklers are installed in a compartment as defined in 3.3.6, all sprinklers within the compartment shall be of the fast-response type that meets the criteria of 3.6.1(a)(1).

8.4.6 Early Suppression Fast-Response (ESFR) Sprinklers.

8.4.6.1 ESFR sprinklers shall be used only in wet pipe systems unless specifically listed for use in dry systems where specifically listed for such service.

8.4.6.2 ESFR sprinklers shall be installed only in buildings where roof or ceiling slope above the sprinklers does not exceed a pitch of two in 12 (a rise of two units in a run of 12 units, a roof slope of 16.7 percent).

8.4.6.3* ESFR sprinklers shall be permitted for use in buildings with unobstructed or obstructed construction. Where depths of the solid structural members (beams, stem, etc.) exceed 12 in., ESFR sprinklers shall be installed in each channel formed by the solid structural members. Minimum sprinkler spacing and area of coverage shall comply with the requirements of 8.12.2 and 8.12.3.

8.4.6.4 Draft Curtains.

8.4.6.4.1 Where ESFR sprinkler systems are installed adjacent to sprinkler systems with standard response sprinklers, a draft curtain of noncombustible construction and at least 2 ft (0.6 m) in depth shall be required to separate the two areas.

8.4.6.4.2 A clear aisle of at least 4 ft (1.2 m) centered below the draft curtain shall be maintained for separation.

8.4.6.5 Temperature Ratings. Sprinkler temperature ratings for ESFR sprinklers shall be ordinary unless 8.3.2 requires intermediate- or high-temperature ratings.

8.4.7 Large Drop Sprinklers.

8.4.7.1 Large drop sprinklers shall be permitted to be used in wet, dry, or preaction systems.

8.4.7.2* Galvanized Pipe.

8.4.7.2.1 Where steel pipe is used in preaction and dry pipe systems, piping materials shall be limited to internally galvanized steel.

8.4.7.2.2 Nongalvanized fittings shall be permitted.

8.4.7.3 Temperature Ratings.

8.4.7.3.1 Unless the requirements of 8.4.7.3.2, 8.4.7.3.3, or 8.4.7.3.4 are met, sprinkler temperature ratings shall be the same as those indicated in Table 8.3.2.5(a) and Table 8.3.2.5(b) or those used in large-scale fire testing to determine the protection requirements for the hazard involved.

8.4.7.3.2 Sprinklers of intermediate- and high-temperature ratings shall be installed in specific locations as required by 8.3.2.

8.4.7.3.3 In storage occupancies, ordinary, intermediate, or high temperature–rated sprinklers shall be used for wet pipe systems.

8.4.7.3.4 In storage occupancies, high temperature–rated sprinklers shall be used for dry pipe systems.

8.4.8 QRES. (Reserved)

8.4.9 Special Sprinklers.

8.4.9.1* Special sprinklers that are intended for the protection of specific hazards or construction features shall be permitted where such devices have been evaluated and listed for performance under the following conditions:

(1) Fire tests related to the intended hazard
(2) Distribution of the spray pattern with respect to wetting of floors and walls
(3) Distribution of the spray pattern with respect to obstructions
(4) Evaluation of the thermal sensitivity of the sprinkler
(5) Performance under horizontal or sloped ceilings
(6) Area of design

8.4.9.2 Special sprinklers shall maintain the following characteristics:

(1) Orifice size shall be in accordance with 6.2.3.
(2) Temperature ratings shall be in accordance with Table 6.2.5.1.
(3) The protection area of coverage shall not exceed 400 ft^2 (36 m^2) for light hazard and ordinary hazard occupancies.
(4) The protection area of coverage shall not exceed 196 ft^2 (17 m^2) for extra hazard and high-piled storage occupancies.

8.5 Position, Location, Spacing, and Use of Sprinklers.

8.5.1 General.

8.5.1.1 Sprinklers shall be located, spaced, and positioned in accordance with the requirements of Section 8.5.

8.5.1.2 Sprinklers shall be positioned to provide protection of the area consistent with the overall objectives of this standard by controlling the positioning and allowable area of coverage for each sprinkler.

8.5.1.3 The requirements of 8.5.2 through 8.5.7 shall apply to all sprinkler types unless modified by more restrictive rules in Sections 8.6 through 8.12.

8.5.2 Protection Areas per Sprinkler.

8.5.2.1 Determination of the Protection Area of Coverage.

8.5.2.1.1 The protection area of coverage per sprinkler (A_s) shall be determined as follows:

(1) Along branch lines as follows:
   (a) Determine distance between sprinklers (or to wall or obstruction in the case of the end sprinkler on the branch line) upstream and downstream.
   (b) Choose the larger of either twice the distance to the wall or the distance to the next sprinkler.
   (c) This dimension will be defined as *S*.
(2) Between branch lines as follows:
   (a) Determine perpendicular distance to the sprinkler on the adjacent branch line (or to a wall or obstruction in the case of the last branch line) on each side of the branch line on which the subject sprinkler is positioned.
   (b) Choose the larger of either twice the distance to the wall or obstruction or the distance to the next sprinkler.
   (c) This dimension will be defined as *L*.

8.5.2.1.2 The protection area of coverage of the sprinkler shall be established by multiplying the *S* dimension by the *L* dimension, as follows: $A_s = S \times L$

8.5.2.2 Maximum Protection Area of Coverage.

8.5.2.2.1 The maximum allowable protection area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in the section for each type or style of sprinkler.

8.5.2.2.2 The maximum area of coverage of any sprinkler shall not exceed 400 ft^2 (36 m^2).

8.5.3 Sprinkler Spacing.

8.5.3.1 Maximum Distance Between Sprinklers.

8.5.3.1.1 The maximum distance permitted between sprinklers shall be based on the centerline distance between sprinklers on the branch line or on adjacent branch lines.

8.5.3.1.2 The maximum distance shall be measured along the slope of the ceiling.

8.5.3.1.3 The maximum distance permitted between sprinklers shall comply with the value indicated in the applicable section for each type or style of sprinkler.

8.5.3.2 Maximum Distance from Walls.

8.5.3.2.1 The distance from sprinklers to walls shall not exceed one-half of the allowable maximum distance between sprinklers.

8.5.3.2.2 The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

8.5.3.3 Minimum Distance from Walls.

8.5.3.3.1 The minimum distance permitted between a sprinkler and the wall shall comply with the value indicated in the applicable section for each type or style of sprinkler.

8.5.3.3.2 The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

8.5.3.4 Minimum Distance Between Sprinklers.

8.5.3.4.1 A minimum distance shall be maintained between sprinklers to prevent operating sprinklers from wetting adjacent sprinklers and to prevent skipping of sprinklers.

8.5.3.4.2 The minimum distance permitted between sprinklers shall comply with the value indicated in the applicable section for each type or style of sprinkler.

8.5.4 Deflector Position.

8.5.4.1* Distance Below Ceilings. The distances between the sprinkler deflector and the ceiling above shall be selected based on the type of sprinkler and the type of construction.

8.5.4.2 Deflector Orientation. Deflectors of sprinklers shall be aligned parallel to ceilings, roofs, or the incline of stairs.

8.5.5 Obstructions to Sprinkler Discharge.

8.5.5.1* Performance Objective. Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.5.5.2 and 8.5.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard. *(See Figure A.8.5.5.1.)*

8.5.5.2* Obstructions to Sprinkler Discharge Pattern Development.

8.5.5.2.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with 8.5.5.2.

8.5.5.2.2 Sprinklers shall be positioned in accordance with the minimum distances and special requirements of Sections 8.6 through 8.12 so that they are located sufficiently away from obstructions such as truss webs and chords, pipes, columns, and fixtures.

8.5.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard. Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with 8.5.5.3.

8.5.5.3.1 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.5.5.3.2 Sprinklers shall not be required under obstructions that are not fixed in place such as conference tables.

8.5.5.3.3 Sprinklers installed under open gratings shall be of the intermediate level/rack storage type or otherwise shielded from the discharge of overhead sprinklers.

8.5.6* Clearance to Storage.

8.5.6.1 Unless the requirements of 8.5.6.2, 8.5.6.3, 8.5.6.4, or 8.5.6.5 are met, the clearance between the deflector and the top of storage shall be 18 in. (457 mm) or greater.

8.5.6.2 Where other standards specify greater clearance to storage minimums, they shall be followed.

8.5.6.3 A minimum clearance to storage of 36 in. (0.91 m) shall be permitted for special sprinklers.

8.5.6.4 A minimum clearance to storage of less than 18 in. (457 mm) between the top of storage and ceiling sprinkler deflectors shall be permitted where proven by successful large-scale fire tests for the particular hazard.

8.5.6.5 The clearance from the top of storage to sprinkler deflectors shall be not less than 3 ft (0.9 m) where rubber tires are stored.

8.5.7 Skylights. Sprinklers shall be permitted to be omitted from skylights and similar ceiling pockets not exceeding 32 ft^2 (3 m^2) in area, regardless of hazard classification, that are separated by at least 10 ft (3 m) horizontally from any other skylight or unprotected ceiling pocket.

8.6 Standard Pendent and Upright Spray Sprinklers.

8.6.1 General. All requirements of Section 8.5 shall apply to standard pendent and upright spray sprinklers except as modified in Section 8.6.

8.6.2 Protection Areas per Sprinkler (Standard Pendent and Upright Spray Sprinklers).

8.6.2.1 *Determination of the Protection Area of Coverage.*

8.6.2.1.1 Except as permitted by 8.6.2.1.2, the protection area of coverage per sprinkler (A_s) shall be determined in accordance with 8.5.2.1.

8.6.2.1.2 The requirements of 8.6.2.1.1 shall not apply in a small room as defined in 3.3.20; the protection area of coverage for each sprinkler in the small room shall be the area of the room divided by the number of sprinklers in the room.

8.6.2.2 Maximum Protection Area of Coverage.

8.6.2.2.1* The maximum allowable protection area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in Table 8.6.2.2.1(a) through Table 8.6.2.2.1(d).

8.6.2.2.2 In any case, the maximum area of coverage of a sprinkler shall not exceed 225 ft^2 (21 m^2).

8.6.3 Sprinkler Spacing (Standard Pendent and Upright Spray Sprinklers).

8.6.3.1 Maximum Distance Between Sprinklers. The maximum distance permitted between sprinklers shall comply with Table 8.6.2.2.1(a) through Table 8.6.2.2.1(d).

8.6.3.2 Maximum Distance from Walls.

8.6.3.2.1 The distance from sprinklers to walls shall not exceed one-half of the allowable distance between sprinklers as indicated in Table 8.6.2.2.1(a) through Table 8.6.2.2.1(d).

8.6.3.2.2 The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

8.6.3.2.3* The requirements of 8.6.3.2.1 shall not apply where walls are angled or irregular, and the maximum horizontal distance between a sprinkler and any point of floor area protected by that sprinkler shall not exceed 0.75 times the allowable distance permitted between sprinklers, provided the maximum perpendicular distance is not exceeded.

8.6.3.2.4* The requirements of 8.6.3.2.1 shall not apply within small rooms as defined in 3.3.20, sprinklers shall be permitted to be located not more than 9 ft (2.7 m) from any single wall, and sprinkler spacing limitations of 8.6.3 and area limitations of Table 8.6.2.2.1(a) shall not be exceeded.

8.6.3.2.5 Under curved surfaces, the horizontal distance shall be measured at the floor level from the wall, or the intersection of the curved surface and the floor to the nearest sprinkler shall not be greater than one-half the allowable distance between sprinklers.

8.6.3.3 Minimum Distances from Walls. Sprinklers shall be located a minimum of 4 in. (102 mm) from a wall.

8.6.3.4 Minimum Distances Between Sprinklers.

8.6.3.4.1 Unless the requirements of 8.6.3.4.2, 8.6.3.4.3, or 8.6.3.4.4 are met, sprinklers shall be spaced not less than 6 ft (1.8 m) on center.

8.6.3.4.2 Sprinklers shall be permitted to be placed less than 6 ft (1.8 m) on center where the following conditions are satisfied:

(1) Baffles shall be installed and located midway between sprinklers and arranged to protect the actuating elements.
(2) Baffles shall be of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation.
(3) Baffles shall be not less than 8 in. (203 mm) wide and 6 in. (152 mm) high.
(4) The tops of baffles shall extend between 2 in. and 3 in. (51 mm and 76 mm) above the deflectors of upright sprinklers.
(5) The bottoms of baffles shall extend downward to a level at least even with the deflectors of pendent sprinklers.

Table 8.6.2.2.1(a) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for Light Hazard

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft²	m²	ft	m
Noncombustible obstructed and unobstructed and combustible unobstructed with members 3 ft or more on center	Pipe schedule	200	18.6	15	4.6
Noncombustible obstructed and unobstructed and combustible unobstructed with members 3 ft or more on center	Hydraulically calculated	225	20.9	15	4.6
Combustible obstructed with members 3 ft or more on center	All	168	15.6	15	4.6
Combustible obstructed or unobstructed with members less than 3 ft on center	All	130	12.1	15	4.6
Unoccupied attics having combustible wood joist or wood truss construction with members less than 3 ft on center with slopes having a pitch of 4 in 12 or greater	All	120	11.1	8* × 15 (minimum 7 psi) 10* × 12 (minimum 20 psi)	2.4* × 4.6 (minimum 0.48 bar) 3* × 3.7 (minimum 1.34 bar)

*The smaller dimension shall be measured perpendicular to the slope.

Table 8.6.2.2.1(b) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for Ordinary Hazard

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft²	m²	ft	m
All	All	130	12.1	15	4.6

Table 8.6.2.2.1(c) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for Extra Hazard

Construction Type	System Type	Protection Area		Spacing (maximum)	
		ft²	m²	ft	m
All	Pipe schedule	90	8.4	12	3.7
				[In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted]	
All	Hydraulically calculated with density ≥0.25	100	9.3	12	3.7
				[In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted]	
All	Hydraulically calculated with density <0.25	130	12.1	15	4.6

8.6.3.4.3 In-rack sprinklers shall be permitted to be placed less than 6 ft (1.8 m) on center.

8.6.3.4.4 Old-style sprinklers protecting fur storage vaults shall be permitted to be placed less than 6 ft (1.8 m) on center.

8.6.4 Deflector Position (Standard Pendent and Upright Spray Sprinklers).

8.6.4.1 Distance Below Ceilings.

8.6.4.1.1 Unobstructed Construction.

8.6.4.1.1.1 Under unobstructed construction, the distance between the sprinkler deflector and the ceiling shall be a minimum of 1 in. (25.4 mm) and a maximum of 12 in. (305 mm) throughout the area of coverage of the sprinkler.

8.6.4.1.1.2 The requirements of 8.6.4.1.1.1 shall not apply where ceiling-type sprinklers (concealed, recessed, and flush types) have the operating element above the ceiling and the deflector located nearer to the ceiling where installed in accordance with their listing.

Table 8.6.2.2.1(d) Protection Areas and Maximum Spacing (Standard Spray Upright/Standard Spray Pendent) for High-Piled Storage

Construction Type	System Type	Protection Area ft²	Protection Area m²	Spacing (maximum) ft	Spacing (maximum) m
All	Hydraulically calculated with density ≥0.25	100	9.3	12 [In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted]	3.7
All	Hydraulically calculated with density <0.25	130	12.1	15	4.6

8.6.4.1.1.3 The requirements of 8.6.4.1.1.1 shall not apply for light and ordinary hazard occupancies with ceilings of noncombustible or limited combustible construction. Where there is a vertical change in ceiling elevation within the area of coverage of the sprinkler creating a distance of more than 36 in. between the upper ceiling and the sprinkler deflector, a vertical plane extending down from the ceiling at the change in elevation shall be considered a wall for the purpose of sprinkler spacing. Where the distance between the upper ceiling and the sprinkler deflector is less than or equal to 36 in., the sprinklers shall be permitted to be spaced as though the ceiling was flat provided the obstruction rules and ceiling pocket rules are observed. *(See Figure 8.6.4.1.1.3.)*

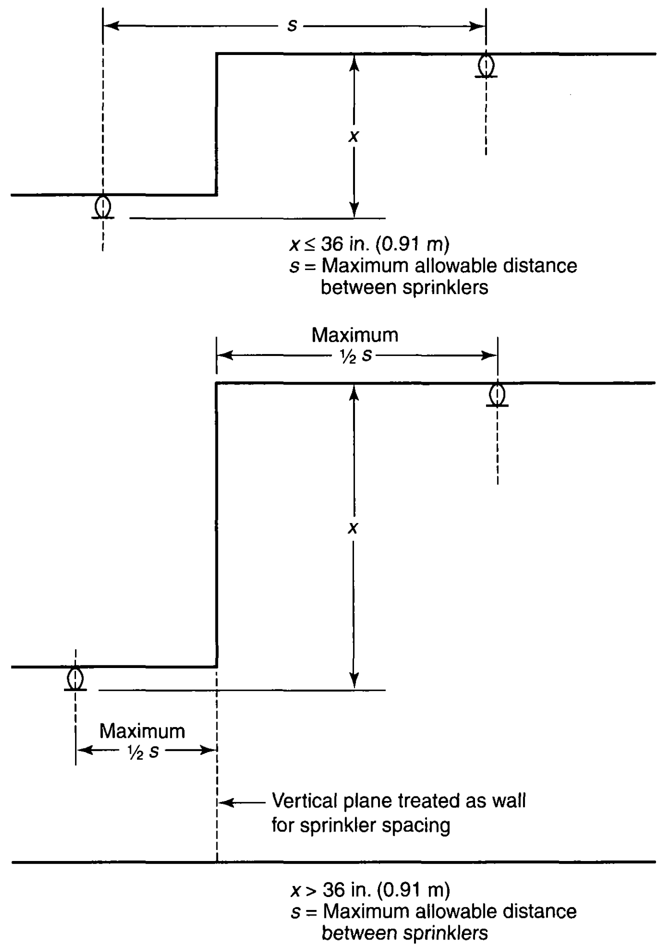


FIGURE 8.6.4.1.1.3 Vertical Changes in Ceiling Elevations.

8.6.4.1.2 Obstructed Construction. Under obstructed construction, the sprinkler deflector shall be located in accordance with one of the following arrangements:

(1) Installed with the deflectors within the horizontal planes of 1 in. to 6 in. (25.4 mm to 152 mm) below the structural members and a maximum distance of 22 in. (559 mm) below the ceiling/roof deck
(2) Installed with the deflectors at or above the bottom of the structural member to a maximum of 22 in. (559 mm) below the ceiling/roof deck where the sprinkler is installed in conformance with 8.6.5.1.2
(3) Installed in each bay of obstructed construction, with the deflectors located a minimum of 1 in. (25.4 mm) and a maximum of 12 in. (305 mm) below the ceiling
(4) Installed with the deflectors within the horizontal planes 1 in. to 6 in. below composite wood joists to a maximum distance of 22 in. below the ceiling/roof deck only where joist channels are fire-stopped to the full depth of the joists with material equivalent to the web construction so that individual channel areas do not exceed 300 ft² (27.9 m²)
(5)*Installed with deflectors of sprinklers under concrete tee construction with stems spaced less than 7½ ft (2.3 m) but more than 3 ft (0.9 m) on centers, regardless of the depth of the tee, located at or above a horizontal plane 1 in. (25.4 mm) below the bottom of the stems of the tees and shall comply with Table 8.6.5.1.2

8.6.4.1.3 Peaked Roofs and Ceilings.

8.6.4.1.3.1 Unless the requirements of 8.6.4.1.3.2 or 8.6.4.1.3.3 are met, sprinklers under or near the peak of a roof or ceiling shall have deflectors located not more than 3 ft (0.9 m) vertically down from the peak as indicated in Figure 8.6.4.1.3.1(a) and Figure 8.6.4.1.3.1(b).

8.6.4.1.3.2* Under saw-toothed roofs, sprinklers at the highest elevation shall not exceed a distance of 3 ft (0.9 m) measured down the slope from the peak.

8.6.4.1.3.3 Under a steeply pitched surface, the distance from the peak to the deflectors shall be permitted to be increased to maintain a horizontal clearance of not less than 2 ft (0.6 m) from other structural members as indicated in Figure 8.6.4.1.3.3.

8.6.4.1.4 Sprinklers Under a Roof or Ceiling in Combustible Concealed Spaces of Wood Joist or Wood Truss Construction with Members 3 ft or Less on Center and a Slope Having a Pitch of Four in 12 or Greater. *(See Figure 8.6.4.1.4.)*

8.6.4.1.4.1 Sprinklers under a roof or ceiling in combustible concealed spaces of wood joist or wood truss construction with members 3 ft or less on center and a slope having a pitch of four in 12 or greater shall be quick response.

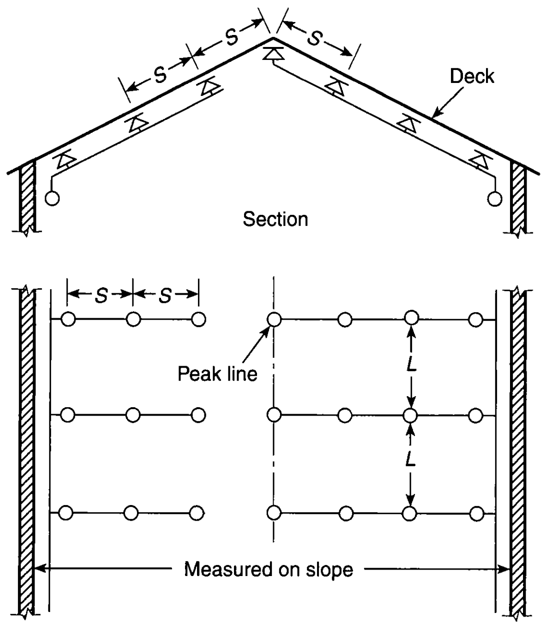


FIGURE 8.6.4.1.3.1(a) Sprinklers Under Pitched Roofs with Sprinkler Directly Under Peak; Branch Lines Run Up the Slope.

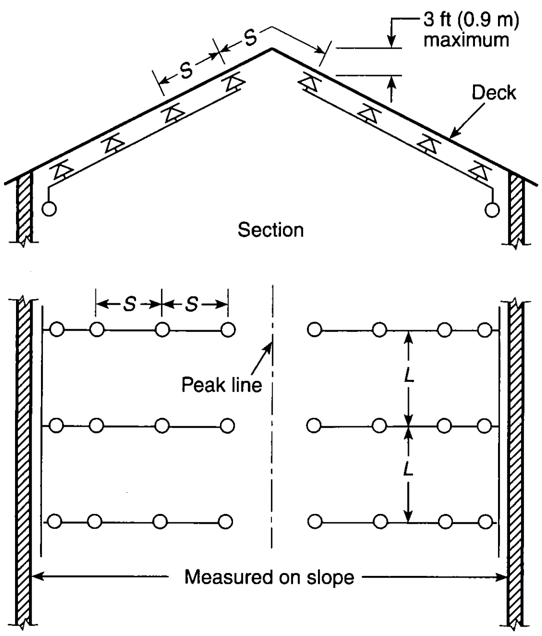


FIGURE 8.6.4.1.3.1(b) Sprinklers at Pitched Roofs; Branch Lines Run Up the Slope.

8.6.4.1.4.2 Sprinklers under a roof or ceiling in combustible concealed spaces of wood joist or wood truss construction with members 3 ft or less on center and a slope having a pitch of four in 12 or greater shall be installed so that a row of sprinklers is installed within 12 in. horizontally of the peak.

8.6.4.1.4.3 Sprinklers under a roof or ceiling in combustible concealed spaces of wood joist or wood truss construction with

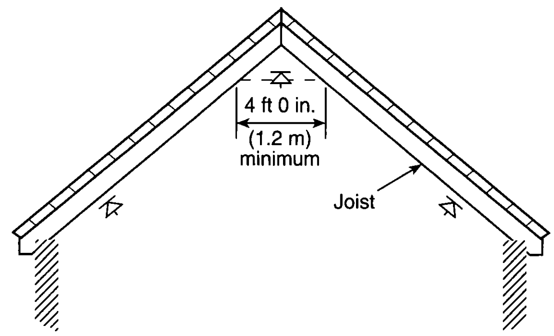


FIGURE 8.6.4.1.3.3 Horizontal Clearance for Sprinklers at Peak of Pitched Roof.

members 3 ft or less on center and a slope having a pitch of four in 12 or greater shall be installed so that the sprinklers installed along the eave are located not less than 6 ft from the outer line of the concealed space.

8.6.4.1.4.4 Nominal K-4.2 orifice sprinklers shall be permitted for use at the 20 psi minimum pressure option for wet pipe systems and dry pipe systems where piping is corrosion resistant or internally galvanized.

8.6.4.1.5 Double Joist Obstructions.

8.6.4.1.5.1 Unless the requirements of 8.6.4.1.5.2 are met, where there are two sets of joists under a roof or ceiling, and there is no flooring over the lower set, sprinklers shall be installed above and below the lower set of joists where there is a clearance of 6 in. (152 mm) or more between the top of the lower joist and the bottom of the upper joist as indicated in Figure 8.6.4.1.5.1.

8.6.4.1.5.2 Sprinklers shall be permitted to be omitted from below the lower set of joists where at least 18 in. (0.46 m) is maintained between the sprinkler deflector and the top of the lower joist.

8.6.4.2* Deflector Orientation.

8.6.4.2.1 Unless the requirements of 8.6.4.2.2, 8.6.4.2.3, or 8.6.4.2.4 are met, deflectors of sprinklers shall be aligned parallel to ceilings, roofs, or the incline of stairs.

8.6.4.2.2 Where sprinklers are installed in the peak below a sloped ceiling or roof surface, the sprinkler shall be installed with the deflector horizontal.

8.6.4.2.3 Pitched roofs having slopes less than 2 in. per foot (16.7 percent) are considered level in the application of 8.6.4.2, and sprinklers shall be permitted to be installed with deflectors horizontal.

8.6.4.2.4 Pitched roofs having slopes not exceeding a pitch of one in six (a rise of two units in a run of 12 units, a roof slope of 16.7 percent) are considered level in the application of this rule, and sprinklers shall be permitted to be installed with deflectors horizontal.

8.6.5 Obstructions to Sprinkler Discharge (Standard Pendent and Upright Spray Sprinklers).

8.6.5.1 Performance Objective.

8.6.5.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.6.5.2 and 8.6.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.

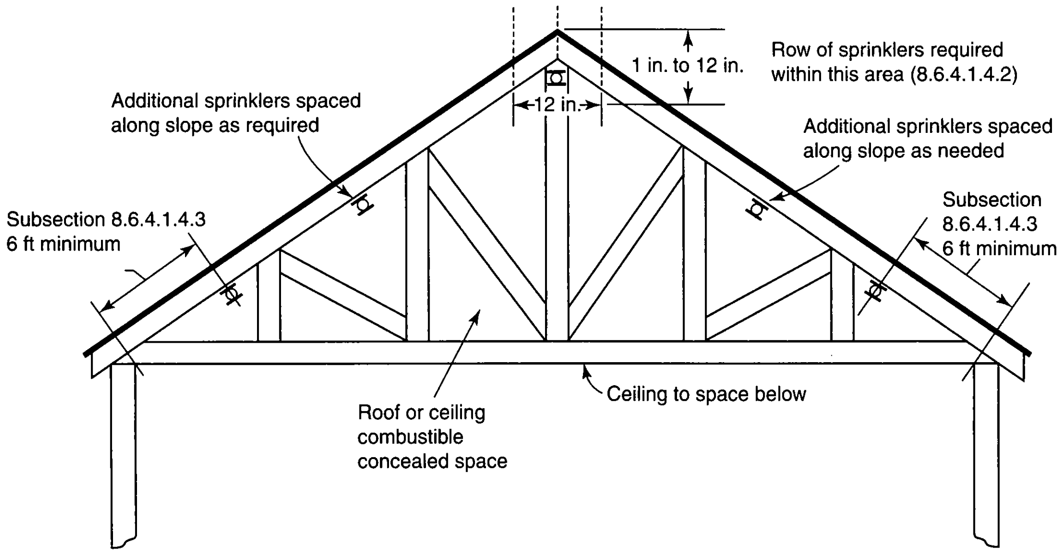


FIGURE 8.6.4.1.4 Sprinklers Under a Roof or Ceiling in Combustible Concealed Spaces of Wood Joist or Wood Truss Construction with Members 3 ft or Less on Center and a Slope Having a Pitch of Four in 12 or Greater.

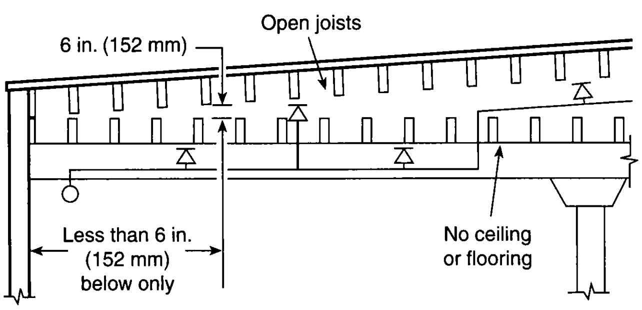


FIGURE 8.6.4.1.5.1 Arrangement of Sprinklers Under Two Sets of Open Joists — No Sheathing on Lower Joists.

8.6.5.1.2 Sprinklers shall be arranged to comply with one of the following arrangements:

(1) Subsection 8.5.5.2, Table 8.6.5.1.2, and Figure 8.6.5.1.2(a).
(2) Sprinklers shall be permitted to be spaced on opposite sides of obstructions not exceeding 4 ft (1.2 m) in width provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance permitted between sprinklers.
(3) Obstructions located against the wall and that are not over 30 in. (762 mm) in width shall be permitted to be protected in accordance with Figure 8.6.5.1.2(b).

8.6.5.2 Obstructions to Sprinkler Discharge Pattern Development.

8.6.5.2.1 General.

8.6.5.2.1.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with 8.6.5.2.

Table 8.6.5.1.2 Positioning of Sprinklers to Avoid Obstructions to Discharge (SSU/SSP)

Distance from Sprinklers to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	2½
1 ft 6 in. to less than 2 ft	3½
2 ft to less than 2 ft 6 in.	5½
2 ft 6 in. to less than 3 ft	7½
3 ft to less than 3 ft 6 in.	9½
3 ft 6 in. to less than 4 ft	12
4 ft to less than 4 ft 6 in.	14
4 ft 6 in. to less than 5 ft	16½
5 ft and greater	18

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.6.5.1.2(a).

8.6.5.2.1.2 Regardless of the rules of 8.6.5.2, solid continuous obstructions shall meet the applicable requirements of 8.6.5.1.2.

8.6.5.2.1.3* Unless the requirements of 8.6.5.2.1.4 through 8.6.5.2.1.10 are met, sprinklers shall be positioned away from obstructions a minimum distance of three times the maximum dimension of the obstruction (e.g., structural members, pipe, columns, and fixtures). The maximum clear distance required shall be 24 in. (609 mm) in accordance with Figure 8.6.5.2.1.3.

8.6.5.2.1.4* For light and ordinary hazard occupancies, structural members only shall be considered when applying the requirements of 8.6.5.2.1.3.

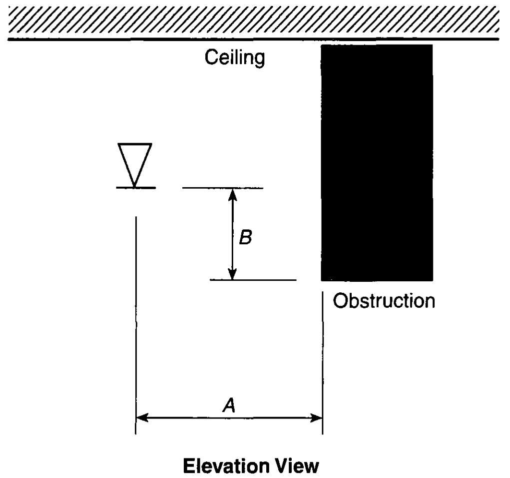


FIGURE 8.6.5.1.2(a) Positioning of Sprinklers to Avoid Obstructions to Discharge (SSU/SSP).

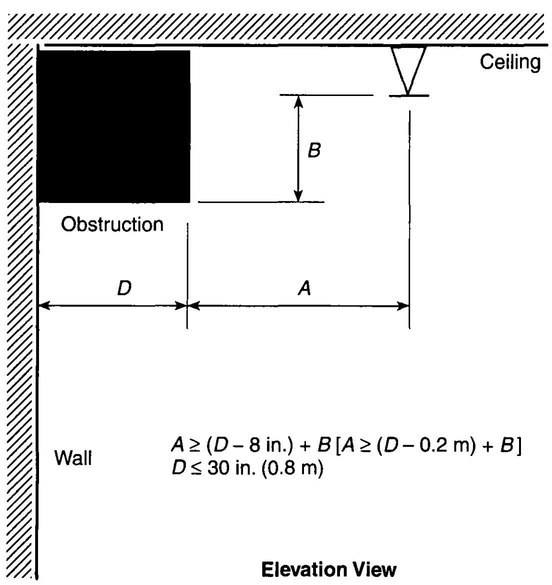


FIGURE 8.6.5.1.2(b) Obstructions Against Walls (SSU/SSP).

8.6.5.2.1.5 Sprinklers shall be permitted to be spaced on opposite sides of the obstruction where the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance between sprinklers.

8.6.5.2.1.6 Sprinklers shall be permitted to be located one-half the distance between the obstructions where the obstruction consists of open trusses 20 in. (0.51 m) or greater apart [24 in. (0.61 m) on center], provided that all truss members are not greater than 4 in. (102 mm) (nominal) in width.

8.6.5.2.1.7 Sprinklers shall be permitted to be installed on the centerline of a truss or bar joist or directly above a beam provided that the truss chord or beam dimension is not more than 8 in. (203 mm) and the sprinkler deflector is located at least 6 in. (152 mm) above the structural member and where the sprinkler is positioned at a distance three times greater than the maximum dimension of the web members away from the web members.

8.6.5.2.1.8 The requirements of 8.6.5.2.1.3 shall not apply to the piping to which an upright sprinkler is directly attached less than 3 in. (76 mm) in diameter.

8.6.5.2.1.9 The requirements of 8.6.5.2.1.3 shall not apply to the piping to which pendent sprinklers are directly attached.

8.6.5.2.1.10 The requirements of 8.6.5.2.1.3 shall not apply to sprinklers positioned with respect to obstructions in accordance with 8.6.5.1.2.

8.6.5.2.2* Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, free standing partitions, room dividers, and similar obstructions in light hazard occupancies shall be in accordance with Table 8.6.5.2.2 and Figure 8.6.5.2.2.

8.6.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.6.5.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with 8.6.5.3.

8.6.5.3.2 The requirements of 8.6.5.3 shall also apply to obstructions 18 in. or less below the sprinkler for light and ordinary hazard occupancies.

8.6.5.3.3 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.6.5.3.4 Sprinklers shall not be required below obstructions that are not fixed in place, such as conference tables.

8.6.5.3.5 Sprinklers installed under open gratings shall be of the intermediate level/rack storage type or otherwise shielded from the discharge of overhead sprinklers.

8.6.6* Clearance to Storage (Standard Pendent and Upright Spray Sprinklers).

8.6.6.1 The clearance between the deflector and the top of storage shall be 18 in. (457 mm) or greater.

8.6.6.2 Where other standards specify greater clearance to storage minimums, they shall be followed.

8.6.7 Ceiling Pockets.

8.6.7.1 Sprinklers shall be required in all ceiling pockets.

8.6.7.2 The requirements of 8.6.7.1 shall not apply where all of the following are met:

(1) The total volume of the unprotected ceiling pocket does not exceed 1000 ft^3.
(2) The depth of the unprotected pocket does not exceed 36 in.
(3) The entire floor under the unprotected ceiling pocket is protected by the sprinklers at the lower ceiling elevation.
(4) Each unprotected ceiling pocket is separated from any adjacent unprotected ceiling pocket by a minimum 10 ft horizontal distance.
(5) The unprotected ceiling pocket is constructed of noncombustible or limited combustible construction.
(6) Skylights not exceeding 32 ft^2 shall be permitted to have a plastic cover.
(7) Quick response sprinklers are utilized throughout the compartment.

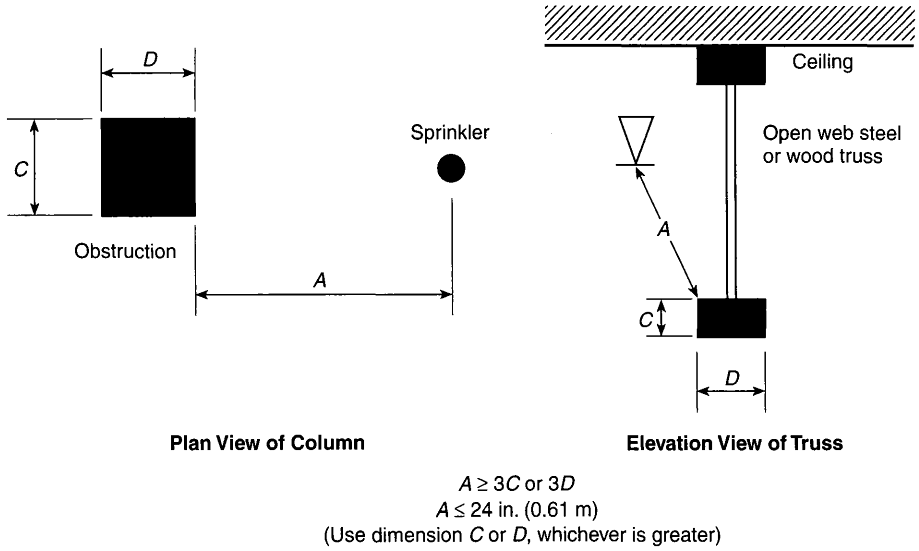


FIGURE 8.6.5.2.1.3 Minimum Distance from Obstruction (SSU/SSP).

Table 8.6.5.2.2 Suspended or Floor-Mounted Obstructions in Light Hazard Occupancies Only (SSU/SSP)

Horizontal Distance *(A)*	Minimum Vertical Distance below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	18

For SI units, 1 in. = 25.4 mm.
Note: For *(A)* and *(B)*, refer to Figure 8.6.5.2.2.

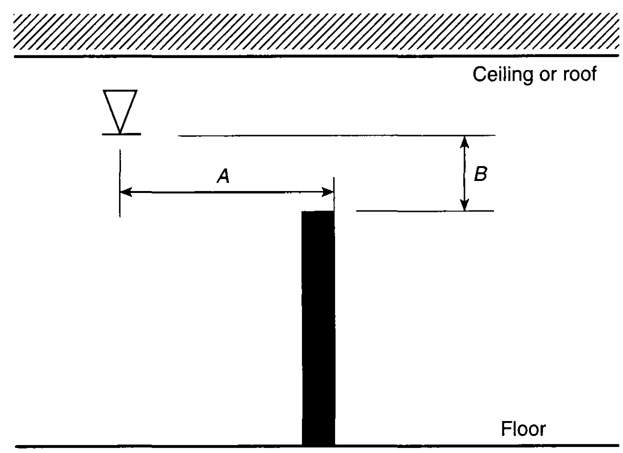


FIGURE 8.6.5.2.2 Suspended or Floor-Mounted Obstructions in Light Hazard Occupancies Only (SSU/SSP).

8.7 Sidewall Standard Spray Sprinklers.

8.7.1 General. All requirements of Section 8.5 shall apply to sidewall standard spray sprinklers except as modified in Section 8.7.

8.7.2 Protection Areas per Sprinkler (Standard Sidewall Spray Sprinklers).

8.7.2.1 Determination of the Protection Area of Coverage.

8.7.2.1.1 The protection area of coverage per sprinkler (A_s) shall be determined as follows:

(1) Along the wall as follows:
   (a) Determine the distance between sprinklers along the wall (or to the end wall or obstruction in the case of the end sprinkler on the branch line) upstream and downstream.
   (b) Choose the larger of either twice the distance to the end wall or the distance to the next sprinkler.
   (c) This dimension will be defined as *S*.
(2) Across the room as follows:
   (a) Determine the distance from the sprinkler to the wall opposite the sprinklers or to the midpoint of the room where sprinklers are installed on two opposite walls *(see 8.7.3.1.5 and 8.7.3.1.6)*.
   (b) This dimension will be defined as *L*.

8.7.2.1.2 The protection area of the sprinkler shall be established by multiplying the *S* dimension by the *L* dimension, as follows: $A_s = S \times L$

8.7.2.2 Maximum Protection Area of Coverage.

8.7.2.2.1 The maximum allowable protection area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in Table 8.7.2.2.1.

8.7.2.2.2 In any case, the maximum area of coverage of a sprinkler shall not exceed 196 ft^2 (18.2 m^2).

Table 8.7.2.2.1 Protection Areas and Maximum Spacing (Standard Sidewall Spray Sprinkler)

	Light Hazard		Ordinary Hazard	
	Combustible Finish	Noncombustible or Limited-Combustible Finish	Combustible Finish	Noncombustible or Limited-Combustible Finish
Maximum distance along the wall *(S)*	14 ft	14 ft	10 ft	10 ft
Maximum room width *(L)*	12 ft	14 ft	10 ft	10 ft
Maximum protection area	120 ft^2	196 ft^2	80 ft^2	100 ft^2

For SI units, 1 ft = 0.3048 m; 1 ft^2 = 0.0929 m^2.

8.7.3 Sprinkler Spacing (Standard Sidewall Spray Sprinklers).

8.7.3.1 Maximum Distance Between Sprinklers.

8.7.3.1.1 The maximum distance permitted between sidewall spray sprinklers shall be based on the centerline distance between sprinklers on the branch line.

8.7.3.1.2 The maximum distance between sidewall spray sprinklers or to a wall shall be measured along the slope of the ceiling.

8.7.3.1.3 Where sidewall spray sprinklers are installed along the length of a single wall of rooms or bays, they shall be spaced in accordance with the maximum spacing provisions of Table 8.7.2.2.1.

8.7.3.1.4 Sidewall spray sprinklers shall not be installed back-to-back without being separated by a continuous lintel or soffit.

8.7.3.1.5 Where sidewall spray sprinklers are installed on two opposite walls or sides of bays, the maximum width of the room or bay shall be permitted to be up to 24 ft (7.32 m) for light hazard occupancy or 20 ft (6.1 m) for ordinary hazard occupancy, with spacing as required by Table 8.7.2.2.1.

8.7.3.1.6 Sidewall spray sprinklers shall be permitted to be installed on opposing or adjacent walls provided no sprinkler is located within the maximum protection area of another sprinkler.

8.7.3.2 Maximum Distance from Walls. The distance from sprinklers to the end walls shall not exceed one-half of the allowable distance permitted between sprinklers as indicated in Table 8.7.2.2.1.

8.7.3.3 Minimum Distance from Walls.

8.7.3.3.1 Sprinklers shall be located a minimum of 4 in. (102 mm) from an end wall.

8.7.3.3.2 The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

8.7.3.4 Minimum Distance Between Sprinklers. Sprinklers shall be spaced not less than 6 ft (1.8 m) on center.

8.7.4 Deflector Position from Ceilings and Walls (Standard Sidewall Spray Sprinklers).

8.7.4.1 Distance Below Ceilings and from Walls.

8.7.4.1.1 Ceilings.

8.7.4.1.1.1 Unless the requirements of 8.7.4.1.1.2 are met, sidewall sprinkler deflectors shall be located not more than 6 in. (152 mm) or less than 4 in. (102 mm) from ceilings.

8.7.4.1.1.2 Horizontal sidewall sprinklers shall be permitted to be located in a zone 6 in. to 12 in. (152 mm to 305 mm) or 12 in. to 18 in. (305 mm to 457 mm) below noncombustible and limited-combustible ceilings where listed for such use.

8.7.4.1.2 Walls.

8.7.4.1.2.1 Vertical sidewall sprinkler deflectors shall be located not more than 6 in. (152 mm) or less than 4 in. (102 mm) from the wall they are projecting from.

8.7.4.1.2.2 Horizontal sidewall sprinkler deflectors shall be located no more than 6 in. (152 mm) and are permitted to be located with their deflectors less than 4 in. (102 mm) from the wall on which they are mounted.

8.7.4.1.3 Lintels and Soffits.

8.7.4.1.3.1 Sidewall sprinklers shall only be installed along walls, lintels, or soffits where the distance from the ceiling to the bottom of the lintel or soffit is at least 2 in. (51 mm) greater than the distances from the ceiling to sidewall sprinkler deflectors.

8.7.4.1.3.2 Where soffits used for the installation of sidewall sprinklers exceed 8 in. (203 mm) in width or projection from the wall, additional sprinklers shall be installed below the soffit.

8.7.4.2 Deflector Orientation.

8.7.4.2.1 Deflectors of sprinklers shall be aligned parallel to ceilings or roofs.

8.7.4.2.2 Sidewall sprinklers, where installed under a sloped ceiling with a slope exceeding 2 in 12, shall be located at the high point of the slope and positioned to discharge downward along the slope.

8.7.5 Obstructions to Sprinkler Discharge (Standard Sidewall Spray Sprinklers).

8.7.5.1 Performance Objective.

8.7.5.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.5.5.2 and 8.5.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.

8.7.5.1.2 Sidewall sprinklers shall be installed no closer than 4 ft (1.2 m) from light fixtures or similar obstructions.

8.7.5.1.3 The distance between light fixtures or similar obstructions located more than 4 ft (1.2 m) from the sprinkler shall be in conformity with Table 8.7.5.1.3 and Figure 8.7.5.1.3.

Table 8.7.5.1.3 Positioning of Sprinklers to Avoid Obstructions (Standard Sidewall Spray Sprinklers)

Distance from Sidewall Sprinkler to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 4 ft	Not allowed
4 ft to less than 5 ft	1
5 ft to less than 5 ft 6 in.	2
5 ft 6 in. to less than 6 ft	3
6 ft to less than 6 ft 6 in.	4
6 ft 6 in. to less than 7 ft	6
7 ft to less than 7 ft 6 in.	7
7 ft 6 in. to less than 8 ft	9
8 ft to less than 8 ft 6 in.	11
8 ft 6 in. or greater	14

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.7.5.1.3.

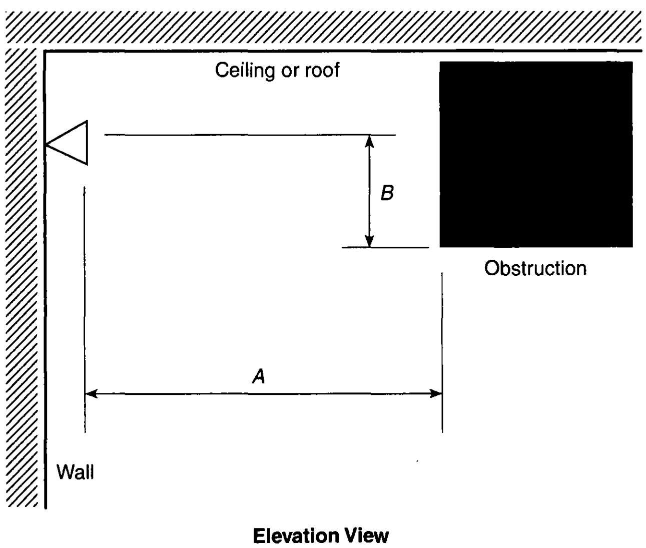


FIGURE 8.7.5.1.3 Positioning of Sprinklers to Avoid Obstructions (Standard Sidewall Spray Sprinklers).

Table 8.7.5.1.4 Positioning of Sprinklers to Avoid Obstructions Along the Wall (Standard Sidewall Spray Sprinklers)

Distance from Sidewall Sprinkler to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 6 in.	1
6 in. to less than 1 ft	2
1 ft to less than 1 ft 6 in.	3
1 ft 6 in. to less than 2 ft	4½
2 ft to less than 2 ft 6 in.	5¾
2 ft 6 in. to less than 3 ft	7
3 ft to less than 3 ft 6 in.	8
3 ft 6 in. to less than 4 ft	9¼
4 ft to less than 4 ft 6 in.	10
4 ft 6 in. to less than 5 ft	11½
5 ft to less than 5 ft 6 in.	12¾
5 ft 6 in. to less than 6 ft	14
6 ft to less than 6 ft 6 in.	15
6 ft 6 in. to less than 7 ft	16¼
7 ft to less than 7 ft 6 in.	17½

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.7.5.1.4.

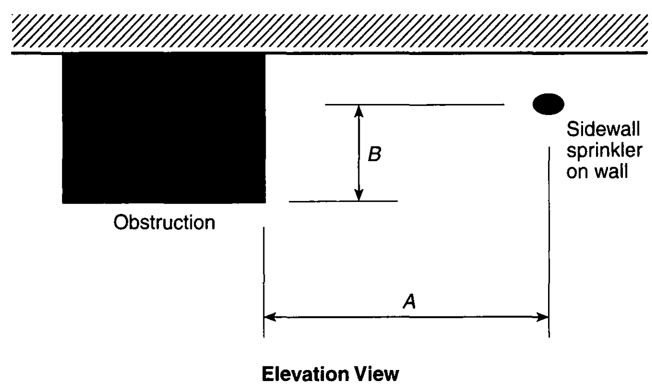


FIGURE 8.7.5.1.4 Positioning of Sprinklers to Avoid Obstructions Along the Wall (Standard Sidewall Spray Sprinklers).

8.7.5.1.4 Obstructions projecting from the same wall as the one on which the sidewall sprinkler is mounted shall be in accordance with Table 8.7.5.1.4 and Figure 8.7.5.1.4.

8.7.5.2 Obstructions to Sprinkler Discharge Pattern Development.

8.7.5.2.1 General.

8.7.5.2.1.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with this section.

8.7.5.2.1.2 Regardless of the rules of this section, solid continuous obstructions shall meet the requirements of 8.7.5.1.2 and 8.7.5.1.3.

8.7.5.2.1.3* Unless the requirements of 8.7.5.2.1.4 or 8.7.5.2.1.5 are met, sprinklers shall be positioned away from obstructions a minimum distance of three times the maximum dimension of the obstruction (e.g., truss webs and chords, pipe, columns, and fixtures). The maximum clear distance required shall be 24 in. (609 mm) and shall be positioned in accordance with Figure 8.7.5.2.1.3 where obstructions are present.

8.7.5.2.1.4 The requirements of 8.7.5.2.1.3 shall not apply to the piping to which sidewall sprinklers are directly attached.

8.7.5.2.1.5 The requirements of 8.7.5.2.1.3 shall not apply where sprinklers are positioned with respect to obstructions in accordance with 8.7.5.1.2, 8.7.5.1.3, and 8.7.5.1.4.

8.7.5.2.2 Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, free-standing partitions, room dividers, and similar obstructions in light hazard occupancies shall be in accordance with Table 8.7.5.2.2 and Figure 8.7.5.2.2.

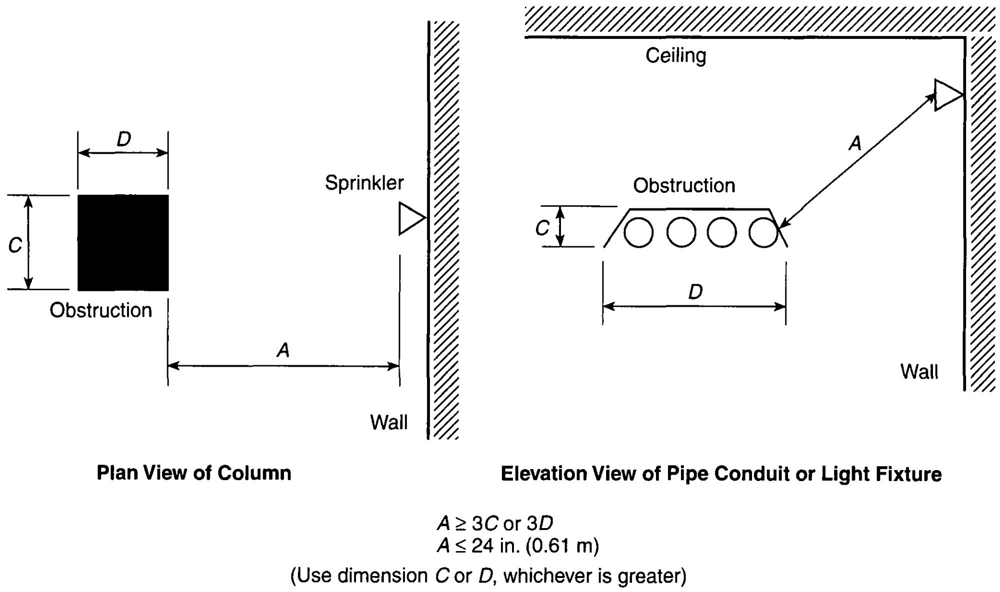


FIGURE 8.7.5.2.1.3 Minimum Distance from Obstruction (Standard Sidewall Spray Sprinkler)

Table 8.7.5.2.2 Suspended or Floor-Mounted Obstructions (Standard Sidewall Spray Sprinklers)

Horizontal Distance *(A)*	Minimum Vertical Distance below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in. to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	18

For SI units, 1 in. = 25.4 mm.
Note: For *(A)* and *(B)*, refer to Figure 8.7.5.2.2.

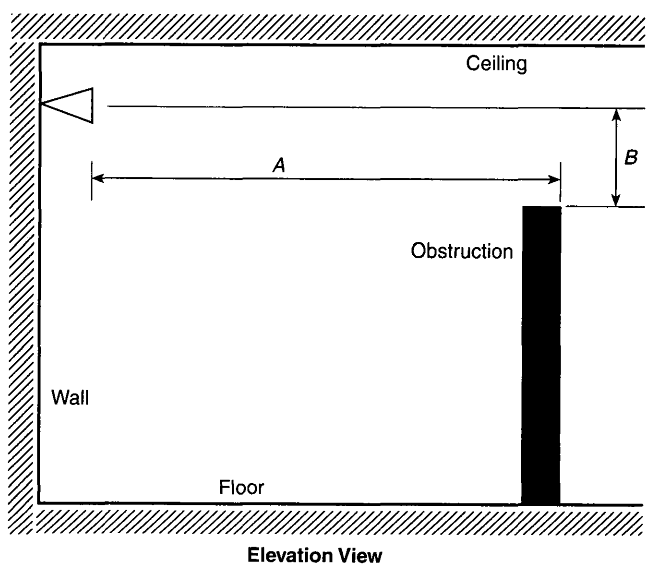


FIGURE 8.7.5.2.2 Suspended or Floor-Mounted Obstructions (Standard Sidewall Spray Sprinklers).

8.7.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.7.5.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with this section.

8.7.5.3.2 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.7.5.3.3 Sprinklers shall not be required under obstructions that are not fixed in place such as conference tables.

8.7.6 Clearance to Storage (Standard Sidewall Spray Sprinklers). The clearance between the deflector and the top of storage shall be 18 in. (457 mm) or greater.

8.8 Extended Coverage Upright and Pendent Spray Sprinklers.

8.8.1 General. All requirements of Section 8.5 shall apply to extended coverage upright and pendent sprinklers except as modified in Section 8.8.

8.8.2 Protection Areas per Sprinkler (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.2.1* Determination of the Protection Area of Coverage.

8.8.2.1.1 The protection area of coverage (A_s) for extended coverage sprinklers shall be not less than that prescribed by the listing.

8.8.2.1.2 Listing dimensions shall be even-numbered square protection areas as shown in Table 8.8.2.1.2.

8.8.2.1.3 Determination of the protection area of coverage and sprinkler spacing for sprinklers listed for extended coverage extra hazard or high-piled storage shall be permitted to be spaced in accordance with the requirements of 8.5.2 and 8.5.3 and shall not exceed 14 ft (4.3 m) maximum spacing and 196 ft^2 (18.2 m^2) maximum area per sprinkler.

8.8.2.2 Maximum Protection Area of Coverage.

8.8.2.2.1 The maximum allowable area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in Table 8.8.2.1.2.

8.8.2.2.2 In any case, the maximum area of coverage of a sprinkler shall not exceed 400 ft^2 (37.1 m^2).

8.8.3 Sprinkler Spacing (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.3.1 Maximum Distance Between Sprinklers.

8.8.3.1.1 The maximum distance permitted between sprinklers shall be based on the centerline distance between sprinklers on the branch line or on adjacent branch lines.

8.8.3.1.2 The maximum distance shall be measured along the slope of the ceiling.

8.8.3.1.3 The maximum distance permitted between sprinklers shall comply with Table 8.8.2.1.2.

8.8.3.2 Maximum Distance from Walls.

8.8.3.2.1 The distance from sprinklers to walls shall not exceed one-half of the allowable distance permitted between sprinklers as indicated in Table 8.8.2.1.2.

8.8.3.2.2 The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

8.8.3.2.3 Where walls are angled or irregular, the maximum horizontal distance between a sprinkler and any point of floor area protected by that sprinkler shall not exceed 0.75 times the allowable distance permitted between sprinklers.

8.8.3.3 Minimum Distance from Walls. Sprinklers shall be located a minimum of 4 in. (102 mm) from a wall unless listed for distances less than 4 in. (102 mm).

8.8.3.4 Minimum Distance Between Sprinklers.

8.8.3.4.1 Unless the requirements of 8.8.3.4.2 are met, sprinklers shall be spaced not less than 8 ft (2.4 m) on center.

8.8.3.4.2 Sprinklers shall be permitted to be placed less than 8 ft (2.4 m) on center where the following conditions are satisfied:

(1) Baffles shall be installed and located midway between sprinklers and arranged to protect the actuating elements.
(2) Baffles shall be of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation.
(3) Baffles shall be not less than 8 in. (203 mm) wide and 6 in. (152 mm) high.
(4) The tops of baffles shall extend between 2 in. and 3 in. (51 mm and 76 mm) above the deflectors of upright sprinklers.
(5) The bottoms of baffles shall extend downward to a level at least even with the deflectors of pendent sprinklers.

8.8.4 Deflector Position (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.4.1 Distance Below Ceilings.

8.8.4.1.1 Unobstructed Construction.

8.8.4.1.1.1 Under unobstructed construction, the distance between the sprinkler deflector and the ceiling shall be a minimum of 1 in. (25.4 mm) and a maximum of 12 in. (305 mm) throughout the area of coverage of the sprinkler.

8.8.4.1.1.2 The requirements of 8.8.4.1.1.1 shall not apply where ceiling-type sprinklers (concealed, recessed, and flush types) have the operating element above the ceiling and the deflector located nearer to the ceiling where installed in accordance with their listing.

Table 8.8.2.1.2 Protection Areas and Maximum Spacing (Extended Coverage Upright and Pendent Spray Sprinklers)

	Light Hazard		Ordinary Hazard		Extra Hazard		High-Piled Storage	
Construction Type	Protection Area (ft^2)	Spacing (ft)	Protection Area (ft^2)	Spacing (ft)	Protection Area (ft^2)	Spacing (ft)	Protection Area (ft^2)	Spacing (ft)
Unobstructed	400	20	400	20	—	—	—	—
	324	18	324	18	—	—	—	—
	256	16	256	16	—	—	—	—
	—	—	196	14	196	14	196	14
	—	—	144	12	144	12	144	12
Obstructed noncombustible (when specifically listed for such use)	400	20	400	20	—	—	—	—
	324	18	324	18	—	—	—	—
	256	16	256	16	—	—	—	—
	—	—	196	14	196	14	196	14
	—	—	144	12	144	12	144	12
Obstructed combustible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

For SI units, 1 ft = 0.3048 m; 1 ft^2 = 0.0929 m^2.

8.8.4.1.1.3 The requirements of 8.8.4.1.1.1 shall not apply where sprinklers are listed for use under other ceiling construction features or for different distances where they shall be permitted to be installed in accordance with their listing.

8.8.4.1.1.4 The requirements of 8.8.4.1.1.1 shall not apply for light and ordinary hazard occupancies with ceilings of noncombustible or limited combustible construction. Where there is a vertical change in ceiling elevation within the area of coverage of the sprinkler creating a distance of more than 36 in. between the upper ceiling and the sprinkler deflector, a vertical plane extending down from the ceiling at the change in elevation shall be considered a wall for the purpose of sprinkler spacing. Where the distance between the upper ceiling and the sprinkler deflector is less than or equal to 36 in., the sprinklers shall be permitted to be spaced as though the ceiling was flat provided the obstruction rules and ceiling pocket rules are observed. *(See Figure 8.8.4.1.1.4.)*

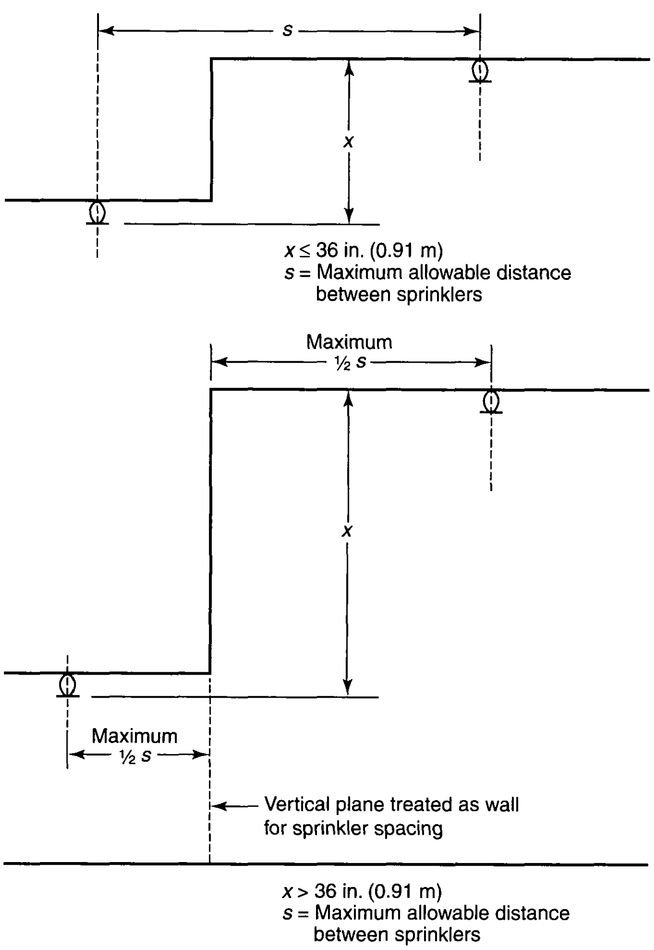


FIGURE 8.8.4.1.1.4 Vertical Changes in Ceiling Elevations.

8.8.4.1.2 Obstructed Construction. Under obstructed construction, the sprinkler deflector shall be located in accordance with one of the following arrangements:

(1) Installed with the deflectors within the horizontal planes of 1 in. to 6 in. (25.4 mm to 152 mm) below the structural members and a maximum distance of 22 in. (559 mm) below the ceiling/roof deck.
(2) Installed with the deflectors at or above the bottom of the structural member to a maximum of 22 in. (559 mm) below the ceiling/roof deck where the sprinkler is installed in conformance with 8.8.5.1.2.
(3) Installed in each bay of obstructed construction, with the deflectors located a minimum of 1 in. (25.4 mm) and a maximum of 12 in. (305 mm) below the ceiling.
(4) Where sprinklers are listed for use under other ceiling construction features or for different distances, they shall be permitted to be installed in accordance with their listing.

8.8.4.1.3* Peaked Roofs and Ceilings. Sprinklers under or near the peak of a roof or ceiling shall have deflectors located not more than 3 ft (0.9 m) vertically down from the peak in accordance with Figure 8.6.4.1.3.1(a) and Figure 8.6.4.1.3.1(b).

8.8.4.2 Deflector Orientation. Deflectors of sprinklers shall be aligned parallel to ceilings or roofs.

8.8.5 Obstructions to Sprinkler Discharge (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.5.1 Performance Objective.

8.8.5.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.8.5.2 and 8.8.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.

8.8.5.1.2 Sprinklers shall be arranged to comply with one of the following arrangements:

(1) Sprinklers shall be in accordance with 8.5.5.2, Table 8.8.5.1.2, and Figure 8.8.5.1.2(a).
(2) Sprinklers shall be permitted to be spaced on opposite sides of obstructions not exceeding 4 ft (1.2 m) in width provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance permitted between sprinklers.
(3) Obstructions located against the wall and that are not over 30 in. (762 mm) in width shall be permitted to be protected in accordance with Figure 8.8.5.1.2(b).

8.8.5.2 Obstructions to Sprinkler Discharge Pattern Development.

8.8.5.2.1 General.

8.8.5.2.1.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with 8.8.5.2.

8.8.5.2.1.2 Regardless of the rules of this section, solid continuous obstructions shall meet the applicable requirements of 8.8.5.1.2.

8.8.5.2.1.3* Unless the requirements of 8.8.5.2.1.4 through 8.8.5.2.1.9 are met, sprinklers shall be positioned away from obstructions a minimum distance of four times the maximum dimension of the obstruction (e.g., truss webs and chords, pipe, columns, and fixtures). The maximum clear distance required shall be 36 in. (0.91 m) in accordance with Figure 8.8.5.2.1.3.

8.8.5.2.1.4 Sprinklers shall be permitted to be spaced on opposite sides of the obstruction where the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance between sprinklers.

Table 8.8.5.1.2 Position of Sprinklers to Avoid Obstructions to Discharge (Extended Coverage Upright and Pendent Spray Sprinklers)

Distance from Sprinklers to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	0
1 ft 6 in. to less than 2 ft	1
2 ft to less than 2 ft 6 in.	1
2 ft 6 in. to less than 3 ft	1
3 ft to less than 3 ft 6 in.	3
3 ft 6 in. to less than 4 ft	3
4 ft to less than 4 ft 6 in.	5
4 ft 6 in. to less than 5 ft	7
5 ft to less than 5 ft 6 in.	7
5 ft 6 in. to less than 6 ft	7
6 ft to less than 6 ft 6 in.	9
6 ft 6 in. to less than 7 ft	11
7 ft and greater	14

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.8.5.1.2(a).

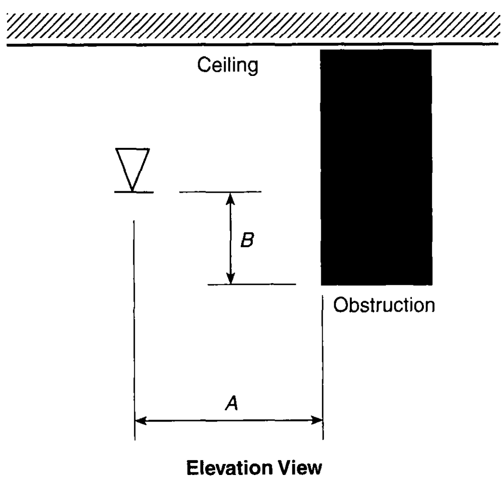


FIGURE 8.8.5.1.2(a) Position of Sprinklers to Avoid Obstructions to Discharge (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.5.2.1.5 Sprinklers shall be permitted to be located one-half the distance between the obstructions where the obstruction consists of open trusses 20 in. (0.51 m) or greater apart [24 in. (0.61 m) on center], provided that all truss members are not greater than 4 in. (102 mm) (nominal) in width and web members do not exceed 1 in. (25.4 mm) in width.

8.8.5.2.1.6 Sprinklers shall be permitted to be installed on the centerline of a truss or bar joist or directly above a beam provided that the truss chord or beam dimension is not more than 8 in. (203 mm) and the sprinkler deflector is located at least 6 in. (152 mm) above the structural member and where the sprinkler is positioned at a distance four times greater than the maximum dimension of the web members away from the web members.

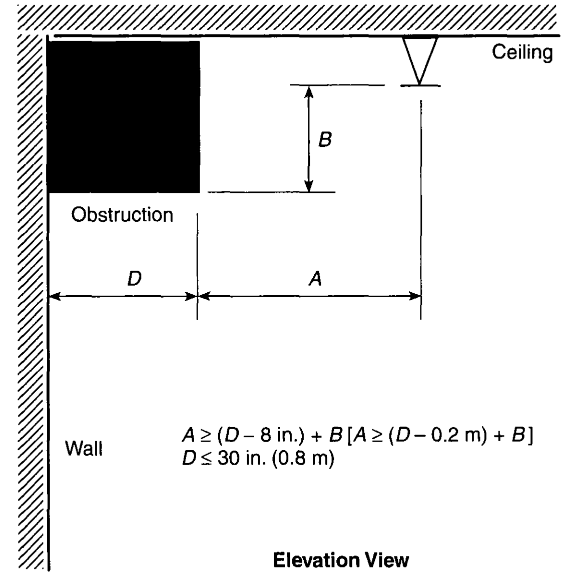


FIGURE 8.8.5.1.2(b) Obstructions Against Walls (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.5.2.1.7 The requirements of 8.8.5.2.1.3 shall not apply to the piping to which an upright sprinkler is directly attached less than 3 in. (75 mm) in diameter.

8.8.5.2.1.8 The requirements of 8.8.5.2.1.3 shall not apply to the piping to which pendent sprinklers are directly attached.

8.8.5.2.1.9 The requirements of 8.8.5.2.1.3 shall not apply to sprinklers positioned with respect to obstructions in accordance with 8.8.5.1.2.

8.8.5.2.2 Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, free-standing partitions, room dividers, and similar obstructions in light hazard occupancies shall be in accordance with Table 8.8.5.2.2 and Figure 8.8.5.2.2.

8.8.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.8.5.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with 8.8.5.3.

8.8.5.3.2 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.8.5.3.3 Sprinklers shall not be required under obstructions that are not fixed in place such as conference tables.

8.8.5.3.4 Sprinklers installed under open gratings shall be of the intermediate level/rack storage type or otherwise shielded from the discharge of overhead sprinklers.

8.8.6 Clearance to Storage (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.6.1 The clearance between the deflector and the top of storage shall be 18 in. (457 mm) or greater.

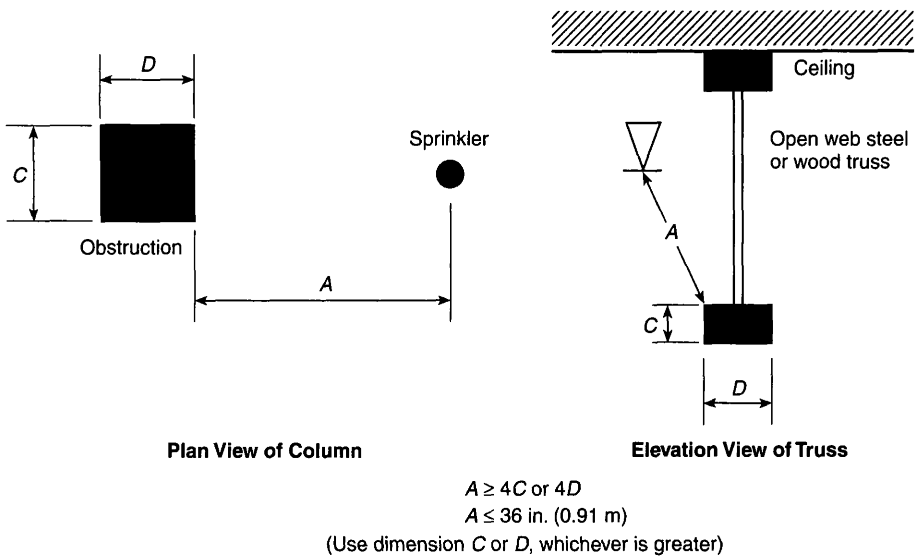


FIGURE 8.8.5.2.1.3 Minimum Distance from Obstruction (Extended Coverage Upright and Pendent Spray Sprinklers).

Table 8.8.5.2.2 Suspended or Floor-Mounted Obstructions (Extended Coverage Upright and Pendent Spray Sprinklers)

Horizontal Distance *(A)*	Minimum Vertical Distance below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in. to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	18

For SI units, 1 in. = 25.4 mm.
Note: For *(A)* and *(B)*, refer to Figure 8.8.5.2.2.

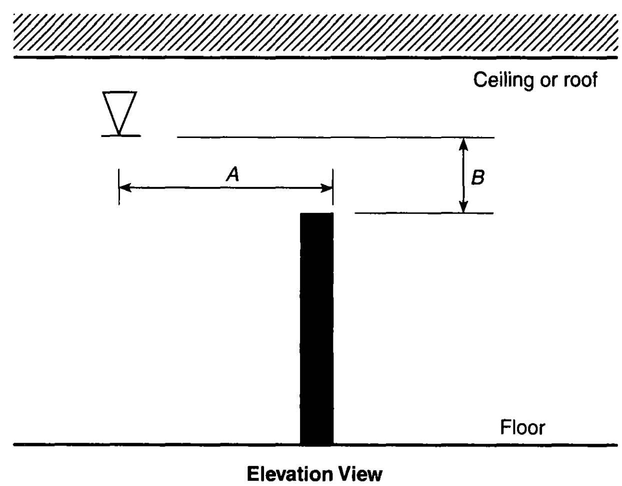


FIGURE 8.8.5.2.2 Suspended or Floor-Mounted Obstructions (Extended Coverage Upright and Pendent Spray Sprinklers).

8.8.6.2 Where other standards specify greater clearance to storage minimums, they shall be followed.

8.8.7 Ceiling Pockets.

8.8.7.1 Sprinklers shall be required in all ceiling pockets.

8.8.7.2 The requirements of 8.8.7.1 shall not apply where all of the following are met:

(1) The total volume of the unprotected ceiling pocket does not exceed 1000 ft^3.
(2) The depth of the unprotected pocket does not exceed 36 in.
(3) The entire floor under the unprotected ceiling pocket is protected by the sprinklers at the lower ceiling elevation.
(4) Each unprotected ceiling pocket is separated from any adjacent unprotected ceiling pocket by a minimum 10 ft horizontal distance.
(5) The unprotected ceiling pocket is constructed of noncombustible or limited combustible construction.
(6) Skylights not exceeding 32 ft^2 shall be permitted to have a plastic cover.
(7) Quick response sprinklers are utilized throughout the compartment.

8.9 Extended Coverage Sidewall Spray Sprinklers.

8.9.1 General. All requirements of Section 8.5 shall apply to extended coverage sidewall spray sprinklers except as modified in Section 8.9.

8.9.2 Protection Areas per Sprinkler (Extended Coverage Sidewall Spray Sprinklers).

8.9.2.1* Determination of the Protection Area of Coverage.

8.9.2.1.1 The protection area of coverage per sprinkler (A_s) for extended coverage sidewall sprinklers shall be not less than that prescribed by the listing.

8.9.2.1.2 Listing dimensions shall be in 2 ft (0.61 m) increments up to 28 ft (8.5 m).

8.9.2.2 Maximum Protection Area of Coverage.

8.9.2.2.1 The maximum allowable protection area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in Table 8.9.2.2.1.

8.9.2.2.2 In any case, the maximum area of coverage of a sprinkler shall not exceed 400 ft^2 (37.1 m^2).

8.9.3 Sprinkler Spacing (Extended Coverage Sidewall Spray Sprinklers).

8.9.3.1 Maximum Distance Between Sprinklers.

8.9.3.1.1 The maximum distance permitted between sprinklers shall be based on the centerline distance between sprinklers on the branch line along the wall.

8.9.3.1.2 Where sprinklers are installed along the length of a single wall of rooms or bays they shall be spaced in accordance with the maximum spacing provisions of Table 8.9.2.2.1.

8.9.3.1.3 Sidewall sprinklers shall not be installed back-to-back without being separated by a continuous lintel, soffit, or baffle.

8.9.3.1.4 Sidewall sprinklers shall be permitted to be installed on opposing or adjacent walls provided no sprinkler is located within the maximum protection area of another sprinkler.

8.9.3.2 Maximum Distance from Walls. The distance from sprinklers to the end walls shall not exceed one-half of the allowable distance permitted between sprinklers as indicated in Table 8.9.2.2.1.

8.9.3.3 Minimum Distance from Walls.

8.9.3.3.1 Sprinklers shall be located a minimum of 4 in. (102 mm) from an end wall.

8.9.3.3.2 The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

8.9.3.4 Minimum Distance Between Sprinklers. No sprinklers shall be located within the maximum protection area of any other sprinkler.

8.9.4 Deflector Position from Ceilings and Walls (Extended Coverage Sidewall Spray Sprinklers).

8.9.4.1 Distance Below Ceilings and from Walls to Which Sprinklers are Mounted.

8.9.4.1.1 Ceilings.

8.9.4.1.1.1 Unless the requirements of 8.9.4.1.1.2 are met, sidewall sprinkler deflectors shall be located not more than 6 in. (152 mm) nor less than 4 in. (102 mm) from ceilings.

8.9.4.1.1.2 Horizontal sidewall sprinklers shall be permitted to be located in a zone 6 in. to 12 in. (152 mm to 305 mm) or 12 in. to 18 in. (305 mm to 457 mm) below noncombustible or limited-combustible ceilings where listed for such use.

8.9.4.1.2 Walls.

8.9.4.1.2.1 Sidewall sprinkler deflectors shall be located not more than 6 in. (152 mm) or less than 4 in. (102 mm) from walls on which they are mounted.

8.9.4.1.2.2 Horizontal sidewall sprinklers shall be permitted to be located with their deflectors less than 4 in. (102 mm) from the wall on which they are mounted.

8.9.4.1.3 Lintels and Soffits.

8.9.4.1.3.1 Sidewall sprinklers shall only be installed along walls, lintels, or soffits where the distance from the ceiling to the bottom of the lintel or soffit is at least 2 in. (51 mm) greater than the distances from the ceiling to sidewall sprinkler deflectors.

8.9.4.1.3.2 Where soffits used for the installation of sidewall sprinklers exceed 8 in. (203 mm) in width or projection from the wall, additional sprinklers shall be installed below the soffit.

8.9.4.2 Deflector Orientation.

8.9.4.2.1 Deflectors of sprinklers shall be aligned parallel to ceilings or roofs.

8.9.4.2.2 Sidewall sprinklers, where installed under a sloped ceiling with a slope exceeding 2 in 12, shall be located at the high point of the slope and positioned to discharge downward along the slope.

8.9.4.2.3 Sidewall sprinklers specifically listed for other ceiling configurations shall be permitted to be installed in accordance with the listing requirements.

8.9.5 Obstructions to Sprinkler Discharge (Extended Coverage Sidewall Spray Sprinklers).

8.9.5.1 Performance Objective.

8.9.5.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.5.5.2 and 8.5.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.

8.9.5.1.2 Sidewall sprinklers shall be installed no closer than 8 ft (2.4 m) from light fixtures or similar obstructions.

8.9.5.1.3 The distance between light fixtures or similar obstructions located more than 8 ft (2.4 m) from the sprinkler shall be in conformity with Table 8.9.5.1.3 and Figure 8.9.5.1.3.

Table 8.9.2.2.1 Protection Area and Maximum Spacing for Extended Coverage Sidewall Sprinklers

	Light Hazard				Ordinary Hazard			
	Protection Area		Spacing		Protection Area		Spacing	
Construction Type	ft^2	m^2	ft	m	ft^2	m^2	ft	m
Unobstructed, smooth, flat	400	37.2	28	8.5	400	37.2	24	7.3

Table 8.9.5.1.3 Positioning of Sprinklers to Avoid Obstructions (Extended Coverage Sidewall Sprinklers)

Distance from Sidewall Sprinkler to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 8 ft	Not allowed
8 ft to less than 10 ft	1
10 ft to less than 11 ft	2
11 ft to less than 12 ft	3
12 ft to less than 13 ft	4
13 ft to less than 14 ft	6
14 ft to less than 15 ft	7
15 ft to less than 16 ft	9
16 ft to less than 17 ft	11
17 ft or greater	14

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.9.5.1.3.

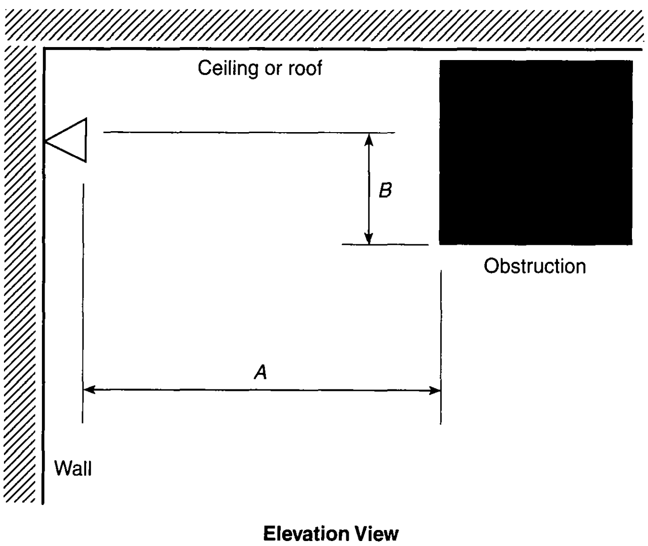


FIGURE 8.9.5.1.3 Positioning of Sprinklers to Avoid Obstructions (Extended Coverage Sidewall Sprinklers).

8.9.5.2 Obstructions to Sprinkler Discharge Pattern Development.

8.9.5.2.1 General.

8.9.5.2.1.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with this section.

8.9.5.2.1.2 Regardless of the rules of this section, solid continuous obstructions shall meet the requirements of 8.9.5.1.2 and 8.9.5.1.3.

8.9.5.2.1.3* Unless the requirements of 8.9.5.2.1.4 or 8.9.5.2.1.5 are met, sprinklers shall be positioned away from obstructions a minimum distance of four times the maximum *dimension of the obstruction* (e.g., truss webs and chords, pipe, columns, and fixtures). The maximum clear distance required shall be 36 in. (0.91 m) from the sprinkler.

8.9.5.2.1.4 Sidewall sprinklers shall be positioned in accordance with Figure 8.9.5.2.1.4 when obstructions are present.

8.9.5.2.1.5 The requirements of 8.9.5.2.1.3 and 8.9.5.2.1.4 shall not apply where sprinklers are positioned with respect to obstructions in accordance with 8.9.5.1.2 and 8.9.5.1.3.

8.9.5.2.2 Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, free-standing partitions, room dividers, and similar obstructions in light hazard occupancies shall be in accordance with Table 8.9.5.2.2 and Figure 8.9.5.2.2.

8.9.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.9.5.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with this section.

8.9.5.3.2 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.9.5.3.3 Sprinklers shall not be required under obstructions that are not fixed in place such as conference tables.

8.10 Residential Sprinklers.

8.10.1 Reserved

8.10.2 Areas of coverage shall be in accordance with the manufacturer's listing.

8.10.3 Distances Between Sprinklers.

8.10.3.1 Maximum distances between sprinklers shall be in accordance with the manufacturer's listing.

8.10.3.2 The distance between the sprinkler and the wall shall not exceed half the maximum allowable distance between sprinklers per the manufacturer's listing.

8.10.3.3 The minimum distance between sprinklers within a compartment shall be 8 ft, unless the listing of the sprinkler requires a greater distance.

8.10.4 Distance Below Ceilings.

8.10.4.1 Pendent and upright sprinklers shall be positioned so that the deflectors are 1 in. to 4 in. from the ceiling unless the listing allows a greater distance.

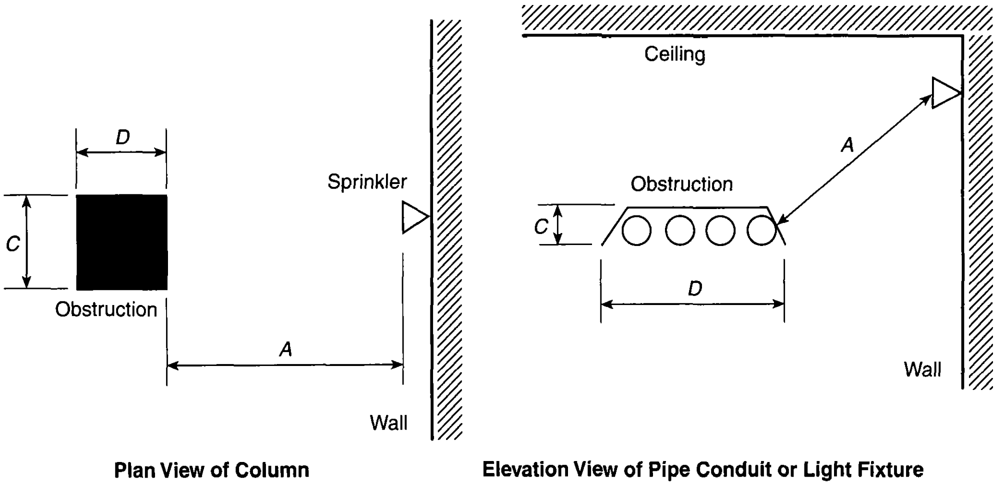
8.10.4.2 Sidewall sprinklers shall be positioned so that the deflectors are within 4 in. to 6 in. from the ceiling unless the listing allows greater distances.

8.10.5 Residential sprinkler installed in conformance with this standard shall follow the sprinkler obstruction rules of 8.10.6 or 8.10.7 as appropriate for their installation orientation (upright, pendent, or sidewall) and the obstruction criteria specified in the manufacturer's installation instructions.

8.10.6 Obstructions to Sprinkler Discharge (Residential Upright and Pendent Spray Sprinklers).

8.10.6.1 Performance Objective.

8.10.6.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.10.6.2 and 8.10.6.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.



$A \geq 4C$ or $4D$
$A \leq 36$ in. (0.91 m)
(Use dimension C or D, whichever is greater)

FIGURE 8.9.5.2.1.4 Minimum Distance from Obstruction (Extended Coverage Sidewall).

Table 8.9.5.2.2 Suspended or Floor-Mounted Obstructions (Extended Coverage Sidewall Sprinklers)

Horizontal Distance *(A)*	Minimum Allowable Distance below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in. to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	18

For SI units, 1 in. = 25.4 mm.
Note: For *(A)* and *(B)*, refer to Figure 8.9.5.2.2.

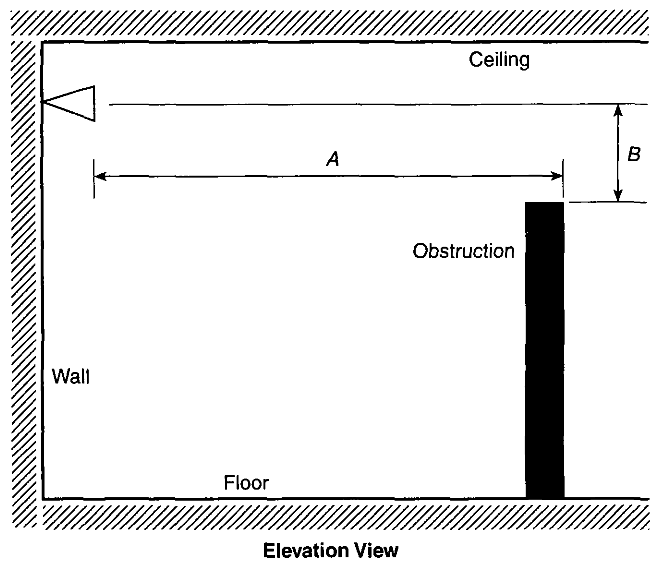


FIGURE 8.9.5.2.2 Suspended or Floor-Mounted Obstructions (Extended Coverage Sidewall Sprinklers).

8.10.6.1.2 Sprinklers shall be arranged to comply with one of the following arrangements:

(1) Sprinklers shall be in accordance with 8.5.5.2, Table 8.10.6.1.2, and Figure 8.10.6.1.2(a).
(2) Sprinklers shall be permitted to be spaced on opposite sides of obstructions not exceeding 4 ft (1.2 m) in width provided the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance permitted between sprinklers.
(3) Obstructions located against the wall and that are not over 30 in. (762 mm) in width shall be permitted to be protected in accordance with Figure 8.10.6.1.2(b).

8.10.6.2 Obstructions to Sprinkler Discharge Pattern Development.

8.10.6.2.1 General.

8.10.6.2.1.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with 8.10.6.2.

8.10.6.2.1.2 Regardless of the rules of this section, solid continuous obstructions shall meet the applicable requirements of 8.10.6.1.2.

8.10.6.2.1.3* Unless the requirements of 8.10.6.2.1.4 through 8.10.6.2.1.9 are met, sprinklers shall be positioned away from obstructions a minimum distance of four times the maximum dimension of the obstruction (e.g., truss webs and chords, pipe, columns, and fixtures). The maximum clear distance required shall be 36 in. (0.91 m) in accordance with Figure 8.10.6.2.1.3.

Table 8.10.6.1.2 Position of Sprinklers to Avoid Obstructions to Discharge (Residential Upright and Pendent Spray Sprinklers)

Distance from Sprinklers to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	0
1 ft 6 in. to less than 2 ft	1
2 ft to less than 2 ft 6 in.	1
2 ft 6 in. to less than 3 ft	1
3 ft to less than 3 ft 6 in.	3
3 ft 6 in. to less than 4 ft	3
4 ft to less than 4 ft 6 in.	5
4 ft 6 in. to less than 5 ft	7
5 ft to less than 5 ft 6 in.	7
5 ft 6 in. to less than 6 ft	7
6 ft to less than 6 ft 6 in.	9
6 ft 6 in. to less than 7 ft	11
7 ft and greater	14

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.10.6.1.2(a).

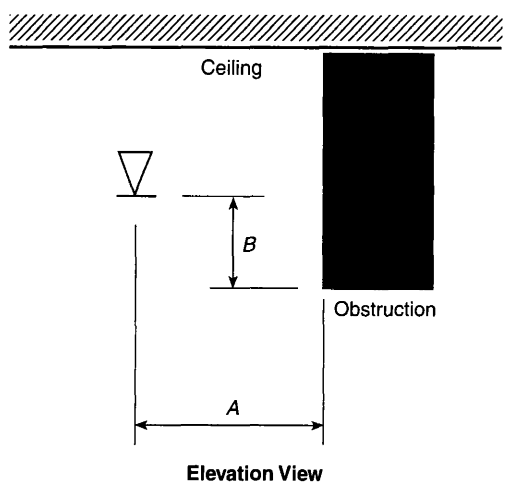


FIGURE 8.10.6.1.2(a) Position of Sprinklers to Avoid Obstructions to Discharge (Residential Upright and Pendent Spray Sprinklers).

8.10.6.2.1.4 Sprinklers shall be permitted to be spaced on opposite sides of the obstruction where the distance from the centerline of the obstruction to the sprinklers does not exceed one-half the allowable distance between sprinklers.

8.10.6.2.1.5 Sprinklers shall be permitted to be located one-half the distance between the obstructions where the obstruction consists of open trusses 20 in. (0.51 m) or greater apart [24 in. (0.61 m) on center], provided that all truss members are not greater than 4 in. (102 mm) (nominal) in width and web members do not exceed 1 in. (25.4 mm) in width.

8.10.6.2.1.6 Sprinklers shall be permitted to be installed on the centerline of a truss or bar joist or directly above a beam provided that the truss chord or beam dimension is not more than 8 in. (203 mm) and the sprinkler deflector is located at least 6 in. (152 mm) above the structural member and where the sprinkler is positioned at a distance four times greater than the maximum dimension of the web members away from the web members.

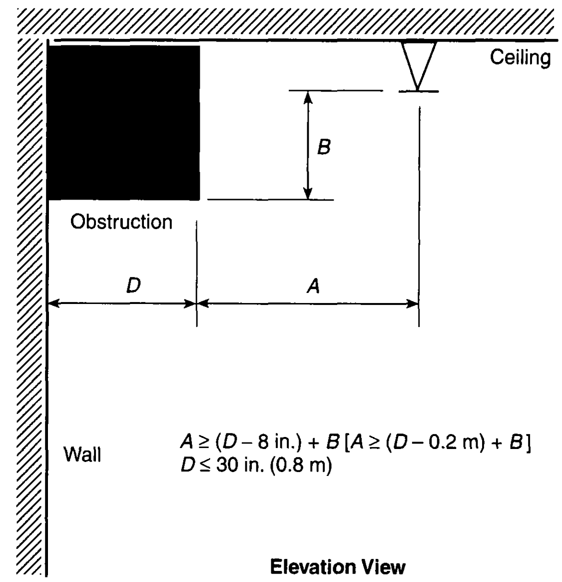


FIGURE 8.10.6.1.2(b) Obstructions Against Walls (Residential Upright and Pendent Spray Sprinklers).

8.10.6.2.1.7 The requirements of 8.10.6.2.1.3 shall not apply to the piping to which an upright sprinkler is directly attached less than 3 in. (75 mm) in diameter.

8.10.6.2.1.8 The requirements of 8.10.6.2.1.3 shall not apply to the piping to which pendent sprinklers are directly attached.

8.10.6.2.1.9 The requirements of 8.10.6.2.1.3 shall not apply to sprinklers positioned with respect to obstructions in accordance with 8.10.6.1.2.

8.10.6.2.2 Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, free-standing partitions, room dividers, and similar obstructions in light hazard occupancies shall be in accordance with Table 8.10.6.2.2 and Figure 8.10.6.2.2.

8.10.6.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.10.6.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with 8.10.6.3.

8.10.6.3.2 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.10.6.3.3 Sprinklers shall not be required under obstructions that are not fixed in place such as conference tables.

8.10.6.3.4 Sprinklers installed under open gratings shall be of the intermediate level/rack storage type or otherwise shielded from the discharge of overhead sprinklers.

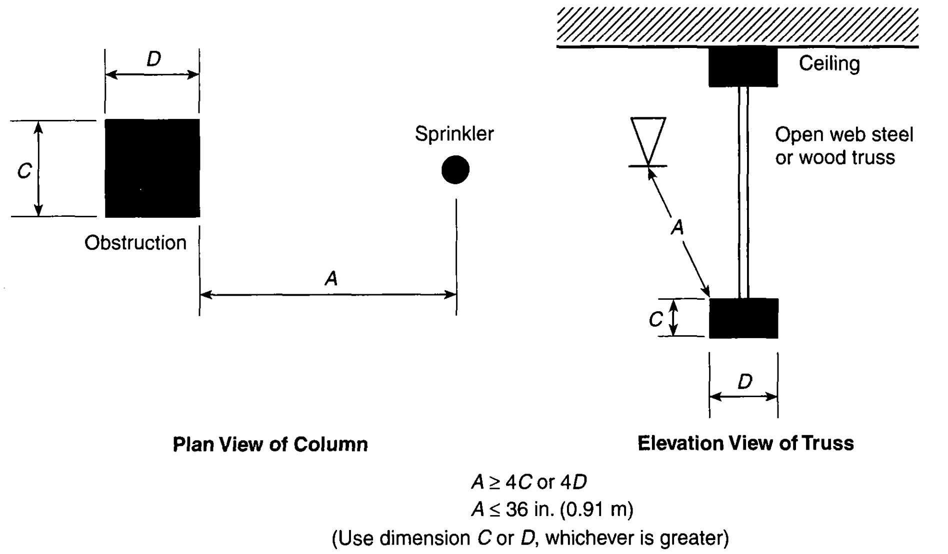


FIGURE 8.10.6.2.1.3 Minimum Distance from Obstruction (Residential Upright and Pendent Spray Sprinklers).

Table 8.10.6.2.2 Suspended or Floor-Mounted Obstructions (Residential Upright and Pendent Spray Sprinklers)

Horizontal Distance *(A)*	Minimum Vertical Distance below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in. to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	18

For SI units, 1 in. = 25.4 mm.
Note: For *(A)* and *(B)*, refer to Figure 8.10.6.2.2.

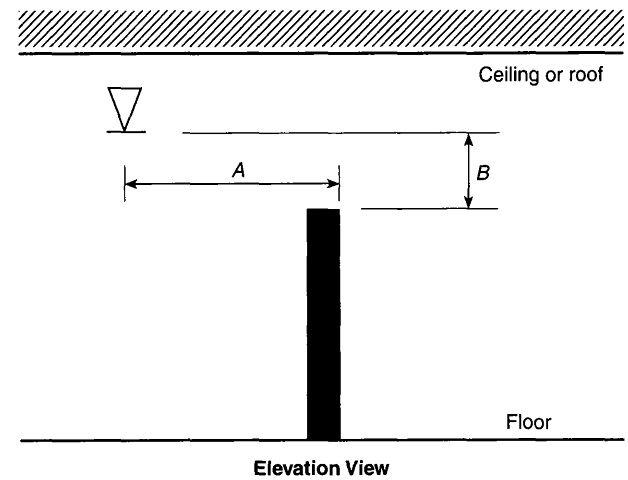


FIGURE 8.10.6.2.2 Suspended or Floor-Mounted Obstructions (Residential Upright and Pendent Spray Sprinklers).

8.10.7 Obstructions to Sprinkler Discharge (Residential Sidewall Spray Sprinklers).

8.10.7.1 Performance Objective.

8.10.7.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.5.5.2 and 8.5.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.

8.10.7.1.2 Sidewall sprinklers shall be installed no closer than 8 ft (2.4 m) from light fixtures or similar obstructions.

8.10.7.1.3 The distance between light fixtures or similar obstructions located more than 8 ft (2.4 m) from the sprinkler shall be in conformity with Table 8.10.7.1.3 and Figure 8.10.7.1.3.

8.10.7.2 Obstructions to Sprinkler Discharge Pattern Development.

8.10.7.2.1 General.

8.10.7.2.1.1 Continuous or noncontinuous obstructions less than or equal to 18 in. (457 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with this section.

8.10.7.2.1.2 Regardless of the rules of this section, solid continuous obstructions shall meet the requirements of 8.10.7.1.2 and 8.10.7.1.3.

8.10.7.2.1.3* Unless the requirements of 8.10.7.2.1.4 or 8.10.7.2.1.5 are met, sprinklers shall be positioned away from obstructions a minimum distance of four times the maximum dimension of the obstruction. The maximum clear distance required shall be 36 in. (0.91 m) from the sprinkler (e.g., truss webs and chords, pipe, columns, and fixtures).

8.10.7.2.1.4 Sidewall sprinklers shall be positioned in accordance with Figure 8.10.7.2.1.4 when obstructions are present.

8.10.7.2.1.5 The requirements of 8.10.7.2.1.3 and 8.10.7.2.1.4 shall not apply where sprinklers are positioned with respect to obstructions in accordance with 8.10.7.1.2 and 8.10.7.1.3.

Table 8.10.7.1.3 Positioning of Sprinklers to Avoid Obstructions (Residential Sidewall Sprinklers)

Distance from Sidewall Sprinkler to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 8 ft	Not Allowed
8 ft to less than 10 ft	1
10 ft to less than 11 ft	2
11 ft to less than 12 ft	3
12 ft to less than 13 ft	4
13 ft to less than 14 ft	6
14 ft to less than 15 ft	7
15 ft to less than 16 ft	9
16 ft to less than 17 ft	11
17 ft or greater	14

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.10.7.1.3.

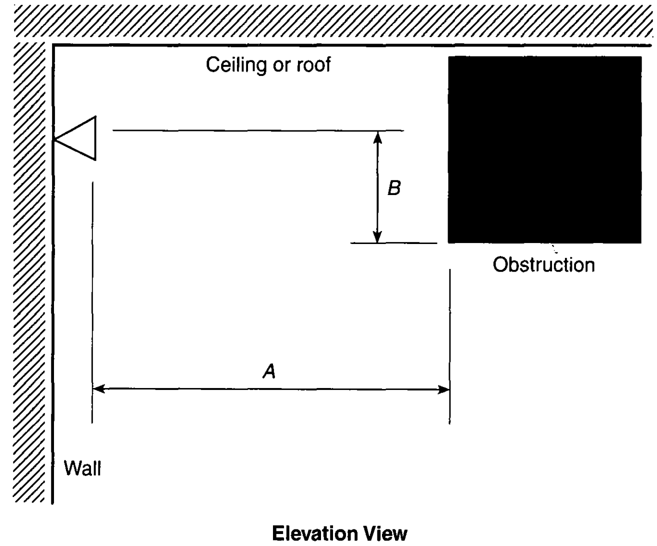


FIGURE 8.10.7.1.3 Positioning of Sprinklers to Avoid Obstructions (Residential Sidewall Sprinklers).

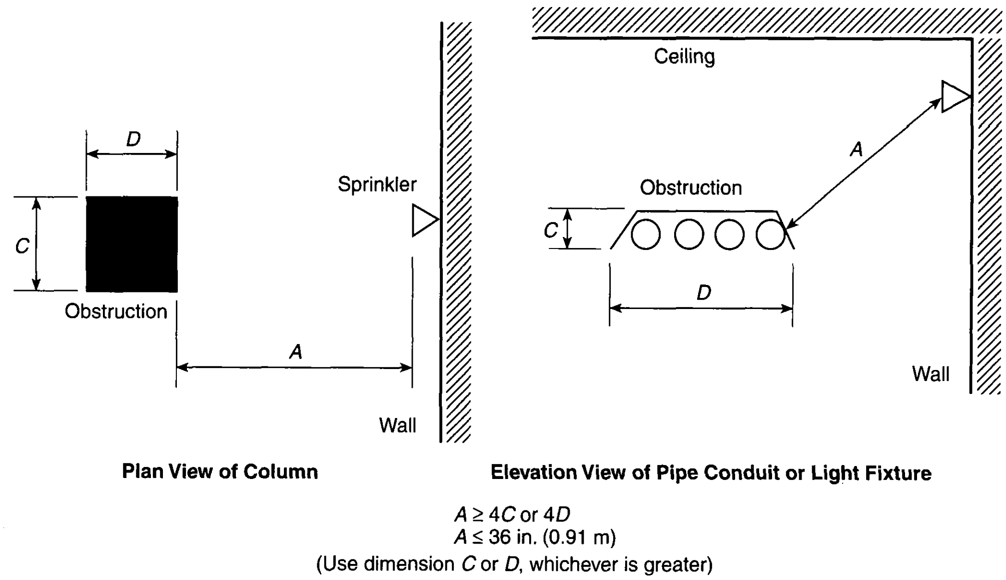


FIGURE 8.10.7.2.1.4 Minimum Distance from Obstruction (Residential Sidewall).

8.10.7.2.2 Suspended or Floor-Mounted Vertical Obstructions. The distance from sprinklers to privacy curtains, freestanding partitions, room dividers, and similar obstructions in light hazard occupancies shall be in accordance with Table 8.10.7.2.2 and Figure 8.10.7.2.2.

8.10.7.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.10.7.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane more than 18 in. (457 mm) below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with this section.

8.10.7.3.2 Sprinklers shall be installed under fixed obstructions over 4 ft (1.2 m) wide such as ducts, decks, open grate flooring, cutting tables, and overhead doors.

8.10.7.3.3 Sprinklers shall not be required under obstructions that are not fixed in place such as conference tables.

8.11 Large Drop Sprinklers in All Applications and Other Specific Application Sprinklers Used for Storage Protection.

8.11.1 General. All requirements of Section 8.5 shall apply to large drop sprinklers except as modified in Section 8.11.

8.11.2* Protection Areas per Sprinkler (Large Drop Sprinklers).

8.11.2.1 Determination of the Protection Area of Coverage. The protection area of coverage per sprinkler (A_s) shall be determined in accordance with 8.5.2.1.

8.11.2.2 Maximum Protection Area of Coverage.

8.11.2.2.1 The maximum allowable protection area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in Table 8.11.2.2.1.

Table 8.10.7.2.2 Suspended or Floor-Mounted Obstructions (Residential Sidewall Sprinklers)

Horizontal Distance *(A)*	Minimum Allowable Distance below Deflector (in.) *(B)*
6 in. or less	3
More than 6 in. to 9 in.	4
More than 9 in. to 12 in.	6
More than 12 in. to 15 in.	8
More than 15 in. to 18 in.	9½
More than 18 in. to 24 in.	12½
More than 24 in. to 30 in.	15½
More than 30 in.	18

For SI units, 1 in. = 25.4 mm.
Note: For *(A)* and *(B)*, refer to Figure 8.10.7.2.2.

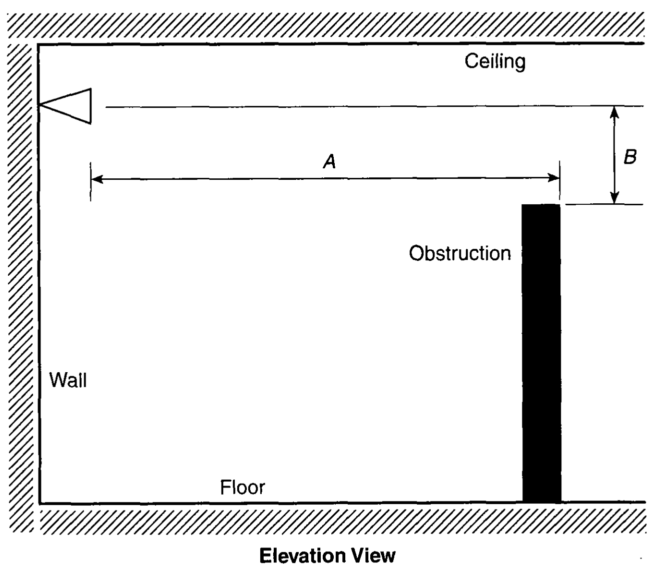


FIGURE 8.10.7.2.2 Suspended or Floor-Mounted Obstructions (Residential Sidewall Sprinklers).

Table 8.11.2.2.1 Protection Areas and Maximum Spacing for Large Drop Sprinklers

	Protection Area		Maximum Spacing	
Construction Type	**ft²**	**m²**	**ft**	**m**
Noncombustible unobstructed	130	12.1	12	3.7
Noncombustible obstructed	130	12.1	12	3.7
Combustible unobstructed	130	12.1	12	3.7
Combustible obstructed	100	9.3	10	3.1
Rack storage applications	100	9.3	10	3.1

8.11.2.2.2 In any case, the maximum area of coverage of any sprinkler shall not exceed 130 ft^2 (12.9 m^2).

8.11.2.3 Minimum Protection Area of Coverage. The minimum allowable protection area of coverage for a sprinkler (A_s) shall be not less than 80 ft^2 (7.4 m^2).

8.11.3 Sprinkler Spacing (Large Drop Sprinklers).

8.11.3.1* Maximum Distance Between Sprinklers.

8.11.3.1.1 Under unobstructed and obstructed noncombustible construction and unobstructed combustible construction, the distance between sprinklers shall be limited to not more than 12 ft (3.7 m) between sprinklers, as shown in Table 8.11.2.2.1.

8.11.3.1.2 Under obstructed combustible construction, the maximum distance shall be limited to 10 ft (3 m).

8.11.3.2 Maximum Distance from Walls. The distance from sprinklers to walls shall not exceed one-half of the allowable distance permitted between sprinklers as indicated in Table 8.11.2.2.1.

8.11.3.3 Minimum Distance from Walls. Sprinklers shall be located a minimum of 4 in. (102 mm) from a wall.

8.11.3.4 Minimum Distance Between Sprinklers. Sprinklers shall be spaced not less than 8 ft (2.4 m) on center.

8.11.4 Deflector Position (Large Drop Sprinklers).

8.11.4.1* Distance Below Ceilings.

8.11.4.1.1 Unobstructed Construction. Under unobstructed construction, the distance between the sprinkler deflector and the ceiling shall be a minimum of 6 in. (152 mm) and a maximum of 8 in. (203 mm).

8.11.4.1.2 Obstructed Construction. Under obstructed construction, the sprinkler deflector shall be located in accordance with one of the following arrangements:

(1) Installed with the deflectors located a minimum of 6 in. (152 mm) and a maximum of 12 in. (305 mm) from the ceiling.
(2) Installed with the deflectors within the horizontal planes 1 in. to 6 in. below wood joist or composite wood joist construction, to a maximum distance of 22 in. (559 mm) below the ceiling/roof or deck.
(3) Installed with deflectors of sprinklers under concrete tee construction with stems spaces less than 7½ ft (2.3 m) but more than 3 ft (0.9 m) on centers, regardless of the depth of the tee, located at or above a horizontal plane 1 in. (25.4 mm) below the bottom of the stems of the tees and shall comply with Table 8.11.5.1.2.

8.11.4.2 Deflector Orientation. Deflectors of sprinklers shall be aligned parallel to ceilings or roofs.

8.11.5* Obstructions to Sprinkler Discharge (Large Drop Sprinklers).

8.11.5.1 Performance Objective.

8.11.5.1.1 Sprinklers shall be located so as to minimize obstructions to discharge as defined in 8.5.5.2 and 8.5.5.3, or additional sprinklers shall be provided to ensure adequate coverage of the hazard.

8.11.5.1.2 Sprinklers shall be arranged to comply with 8.5.5.2, Table 8.11.5.1.2, and Figure 8.11.5.1.2.

Table 8.11.5.1.2 Positioning of Sprinklers to Avoid Obstructions to Discharge (Large Drop Sprinkler)

Distance from Sprinkler to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	1½
1 ft 6 in. to less than 2 ft	3
2 ft to less than 2 ft 6 in.	5½
2 ft 6 in. to less than 3 ft	8
3 ft to less than 3 ft 6 in.	10
3 ft 6 in. to less than 4 ft	12
4 ft to less than 4 ft 6 in.	15
4 ft 6 in. to less than 5 ft	18
5 ft to less than 5 ft 6 in.	22
5 ft 6 in. to less than 6 ft	26
6 ft	31

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.11.5.1.2.

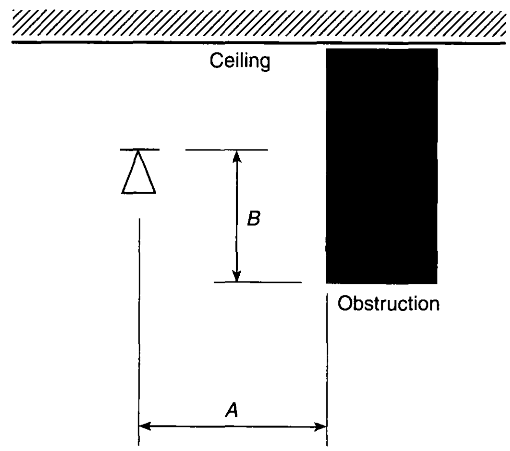


FIGURE 8.11.5.1.2 Positioning of Sprinklers to Avoid Obstructions to Discharge (Large Drop Sprinkler).

8.11.5.1.3 The requirements of 8.11.5.1.2 shall not apply, where sprinklers are positioned on opposite sides of the obstruction.

8.11.5.2 Obstructions to Sprinkler Discharge Pattern Development.

8.11.5.2.1 General.

8.11.5.2.1.1 Continuous or noncontinuous obstructions less than or equal to 36 in. (914 mm) below the sprinkler deflector that prevent the pattern from fully developing shall comply with 8.11.5.2.

8.11.5.2.1.2 Regardless of the rules of this section, solid continuous obstructions shall meet the requirements of 8.11.5.1.2 or 8.11.5.1.3.

8.11.5.2.1.3* Unless the requirements of 8.11.5.1.2 or 8.11.5.1.3 are met, for obstructions 8 in. (203 mm) or less in width, as shown in Figure 8.11.5.2.1.3, sprinklers shall be positioned such that they are located at least a distance three times greater than the maximum dimension of the obstruction from the sprinkler (e.g., webs and chord members, pipe, columns, and fixtures).

8.11.5.2.2 Branch Lines. Sprinklers shall be positioned with respect to branch lines in accordance with one of the following:

(1) Sprinklers shall be permitted to be attached directly to branch lines less than 2 in. (51 mm) in diameter.
(2) Sprinklers shall be permitted to be offset horizontally a minimum of 12 in. (305 mm) from the pipe.
(3) Sprinklers shall be permitted to be supplied by a riser nipple to elevate the sprinkler deflector a minimum of 13 in. (330 mm) from the centerline of 2½-in. (64-mm) pipe.
(4) Sprinklers shall be permitted to be supplied by a riser nipple to elevate the sprinkler deflector a minimum of 15 in. (380 mm) from the centerline of 3-in. (76-mm) pipe.

8.11.5.3* Obstructions that Prevent Sprinkler Discharge from Reaching the Hazard.

8.11.5.3.1 Continuous or noncontinuous obstructions that interrupt the water discharge in a horizontal plane below the sprinkler deflector in a manner to limit the distribution from reaching the protected hazard shall comply with 8.11.5.3.

8.11.5.3.2 Sprinklers shall be positioned with respect to fluorescent lighting fixtures, ducts, and obstructions more than 24 in. (610 mm) wide and located entirely below the sprinklers so that the minimum horizontal distance from the near side of the obstruction to the center of the sprinkler is not less than the value specified in Table 8.11.5.3.2 and Figure 8.11.5.3.2.

8.11.5.3.3 Sprinklers installed under open gratings shall be shielded from the discharge of overhead sprinklers.

8.11.5.3.4 Where the bottom of the obstruction is located 24 in. (610 mm) or more below the sprinkler deflectors, the following shall occur:

(1) Sprinklers shall be positioned so that the obstruction is centered between adjacent sprinklers in accordance with Figure 8.11.5.3.4.
(2) The obstruction width shall meet the following requirements:
    (a) The obstruction shall be limited to a maximum width of 24 in. (610 mm) in accordance with Figure 8.11.5.3.4.
    (b) Where the obstruction is greater than 24 in. (610 mm) wide, one or more lines of sprinklers shall be installed below the obstruction.
(3) The obstruction extension shall meet the following requirements:
    (a) The obstruction shall not extend more than 12 in. (305 mm) to either side of the midpoint between sprinklers in accordance with Figure 8.11.5.3.4.
    (b) Where the extensions of the obstruction exceed 12 in. (305 mm), one or more lines of sprinklers shall be installed below the obstruction.
(4) At least 18 in. (457 mm) clearance shall be maintained between the top of storage and the bottom of the obstruction in accordance with Figure 8.11.5.3.4.

8.11.5.3.5 In the special case of an obstruction running parallel to and directly below a branch line, the following shall occur:

(1) The sprinkler shall be located at least 36 in. (914 mm) above the top of the obstruction in accordance with Figure 8.11.5.3.5.

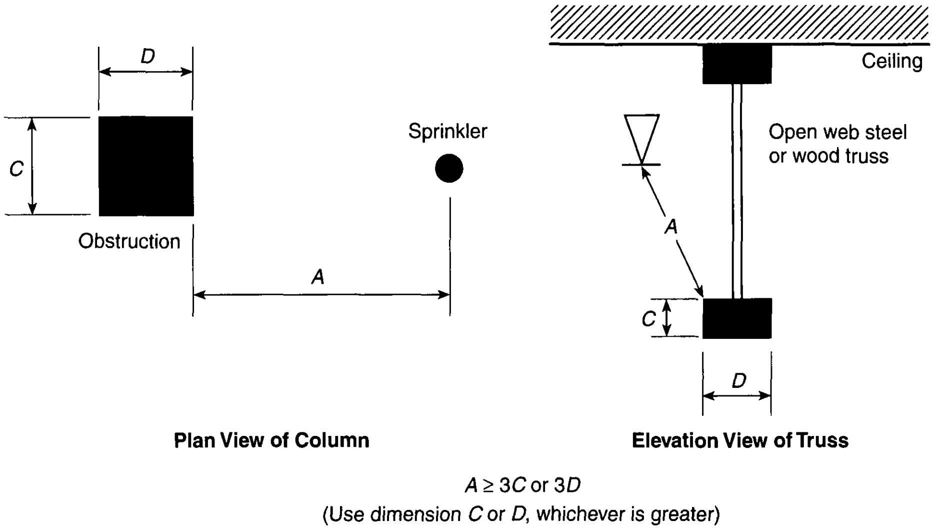


FIGURE 8.11.5.2.1.3 Minimum Distance from Obstruction (Large Drop Sprinkler).

Table 8.11.5.3.2 Obstruction Entirely Below the Sprinkler (Large Drop Sprinkler)

Distance of Deflector above Bottom of Obstruction *(B)*	Minimum Distance to Side of Obstruction (ft) *(A)*
Less than 6 in.	1½
6 in. to less than 12 in.	3
12 in. to less than 18 in.	4
18 in. to less than 24 in.	5
24 in. to less than 30 in.	5½
30 in. less than 36 in.	6

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.11.5.3.2.

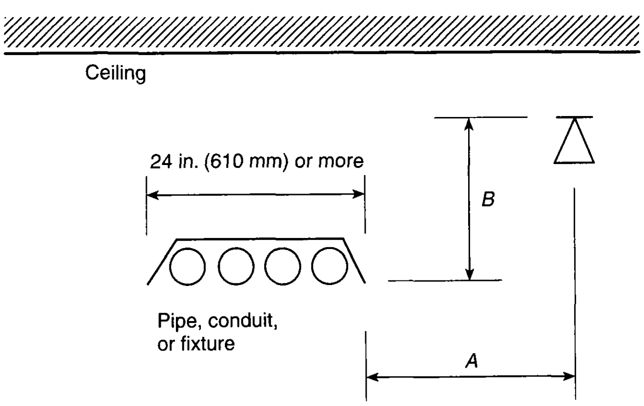


FIGURE 8.11.5.3.2 Obstruction Entirely Below the Sprinkler (Large Drop Sprinkler).

(2) The obstruction shall be limited to a maximum width of 12 in. (305 mm) in accordance with Figure 8.11.5.3.5.
(3) The obstruction shall be limited to a maximum extension of 6 in. (152 mm) to either side of the centerline of the branch line in accordance with Figure 8.11.5.3.5.

8.11.6 Clearance to Storage (Large Drop Sprinklers). The clearance between the deflector and the top of storage shall be 36 in. (914 mm) or greater.

8.12 Early Suppression Fast-Response Sprinklers.

8.12.1 General. All requirements of Section 8.5 shall apply except as modified in Section 8.12.

8.12.2 Protection Areas per Sprinkler (Early Suppression Fast-Response Sprinklers).

8.12.2.1 Determination of the Protection Area of Coverage. The protection area of coverage per sprinkler (A_s) shall be determined in accordance with 8.5.2.1.

8.12.2.2 Maximum Protection Area of Coverage.

8.12.2.2.1 The maximum allowable protection area of coverage for a sprinkler (A_s) shall be in accordance with the value indicated in Table 8.12.2.2.1.

8.12.2.2.2 Unless the requirements of 8.12.2.2.3 are met, the maximum area of coverage of any sprinkler shall not exceed 100 ft^2 (9.3 m^2).

8.12.2.2.3* It shall be permitted to deviate from the maximum sprinkler spacing to eliminate obstructions created by trusses and bar joists by moving a sprinkler along the branch line a maximum of 1 ft (0.31 m) from its allowable spacing provided coverage for that sprinkler does not exceed 110 ft^2 (10.2 m^2) per sprinkler where all of the following conditions are met:

(1) The average actual floor area protected by the moved sprinkler and the adjacent sprinklers does not exceed 100 ft^2 (9.3 m^2).
(2) Adjacent branch lines shall maintain the same pattern.
(3) In no case shall the distance between sprinklers exceed 12 ft (3.7 m).

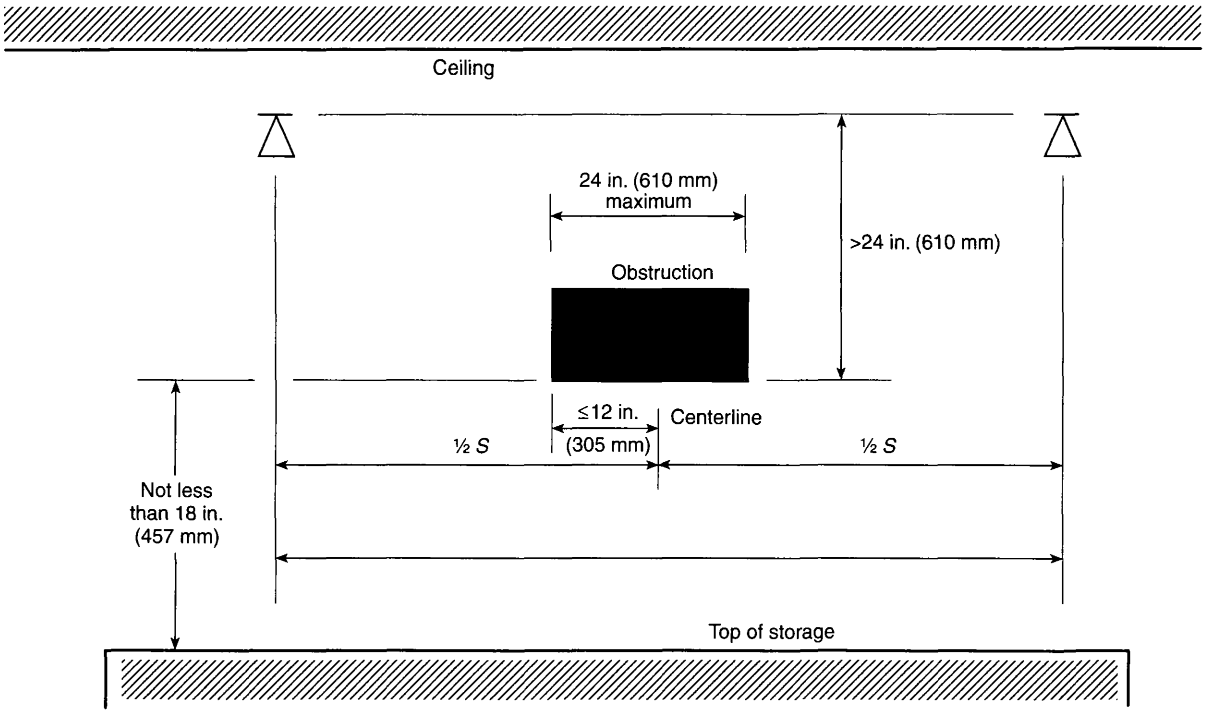


FIGURE 8.11.5.3.4 Obstruction More Than 24 in. (610 mm) Below the Sprinkler (Large Drop Sprinkler).

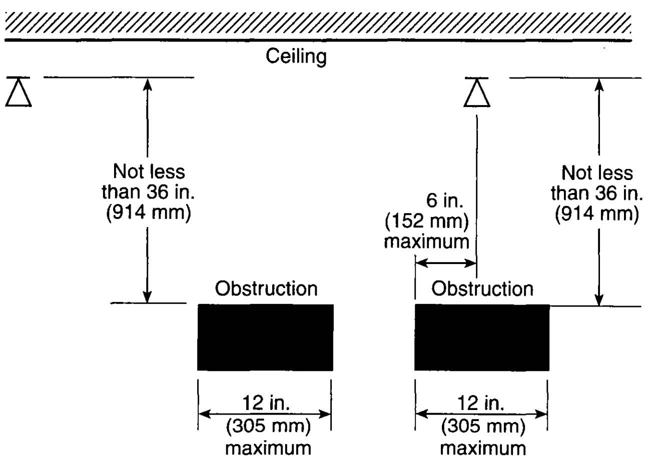


FIGURE 8.11.5.3.5 Obstruction More Than 36 in. (914 mm) Below the Sprinkler (Large Drop Sprinkler).

8.12.2.2.4 Where branch lines are parallel to trusses and bar joists it shall be permitted to deviate from the maximum sprinkler spacing to eliminate obstructions created by trusses and bar joists by moving a single branch line a maximum of 1 ft (0.31 m) from its allowable spacing provided coverage for the sprinklers on that branch line and the sprinklers on the branch line it is moving away from does not exceed 110 ft^2 per sprinkler where all of the following conditions are met:

(1) The average actual floor area protected by the sprinklers on the moved branch line and the sprinklers on the adjacent branch lines does not exceed 100 ft^2 per sprinkler.
(2) In no case shall the distance between sprinklers exceed 12 ft (3.7 m).
(3) It shall not be permitted to move a branch line where there are moved sprinklers on a branch line that exceed the maximum sprinkler spacing.

8.12.2.3 Minimum Protection Area of Coverage. The minimum allowable protection area of coverage for a sprinkler (A_s) shall be not less than 80 ft^2 (7.4 m^2).

8.12.3 Sprinkler Spacing (Early Suppression Fast-Response Sprinklers).

8.12.3.1 Maximum Distance Between Sprinklers. The maximum distance between sprinklers shall be in accordance with the following:

(1) Where the storage height is less than or equal to 25 ft (7.6 m) and the ceiling height is less than or equal to 30 ft (9.1 m), the distance between sprinklers shall be limited to not more than 12 ft (3.7 m) between sprinklers as shown in Table 8.12.2.2.1.
(2) Unless the requirements of 8.12.3.1(3) are met, where the storage height exceeds 25 ft (7.6 m) and ceiling height exceeds 30 ft (9.1 m), the distance between sprinklers shall be limited to not more than 10 ft (3 m) between sprinklers.
(3)*Regardless of the storage or ceiling height arrangement, it shall be permitted to deviate from the maximum sprinkler spacing to eliminate obstructions created by trusses and bar joists by moving a sprinkler along the branch line a maximum of 1 ft (0.31 m) from its allowable spacing provided coverage for that sprinkler does not exceed 110 ft^2 (10.2 m^2) where all of the following conditions are met:
   (a) The average actual floor area protected by the moved sprinkler and the adjacent sprinklers shall not exceed 100 ft^2 (9.3 m^2).
   (b) Adjacent branch lines shall maintain the same pattern.
   (c) In no case shall the distance between sprinklers exceed 12 ft (3.7 m).

Table 8.12.2.2.1 Protection Areas and Maximum Spacing of ESFR Sprinklers

	Ceiling/Roof Heights up to 30 ft (9.1 m)				Ceiling/Roof Heights over 30 ft (9.1 m)			
	Protection Area		Spacing		Protection Area		Spacing	
Construction Type	ft^2	m^2	ft	m	ft^2	m^2	ft	m
Noncombustible unobstructed	100	9.3	12	3.7	100	9.3	10	3.1
Noncombustible obstructed	100	9.3	12	3.7	100	9.3	10	3.1
Combustible unobstructed	100	9.3	12	3.7	100	9.3	10	3.1
Combustible obstructed	N/A		N/A		N/A		N/A	

(4) Where branch lines are parallel to trusses and bar joists it shall be permitted to deviate from the maximum sprinkler spacing to eliminate obstructions created by trusses and bar joists by moving a single branch line a maximum of 1 ft (0.31 m) from its allowable spacing provided coverage for the sprinklers on that branch line and the sprinklers on the branch line it is moving away from does not exceed 110 ft^2 per sprinkler where all of the following conditions are met:

(a) The average actual floor area protected by the sprinklers on the moved branch line and the sprinklers on the adjacent branch lines shall not exceed 100 ft^2 per sprinkler.

(b) In no case shall the distance between sprinklers exceed 12 ft (3.7 m).

(c) It shall not be permitted to move a branch line where there are moved sprinklers on a branch line that exceed the maximum sprinkler spacing.

8.12.3.2 Maximum Distance from Walls. The distance from sprinklers to walls shall not exceed one-half of the allowable distance permitted between sprinklers as indicated in Table 8.12.2.2.1.

8.12.3.3 Minimum Distance from Walls. Sprinklers shall be located a minimum of 4 in. (102 mm) from a wall.

8.12.3.4 Minimum Distance Between Sprinklers. Sprinklers shall be spaced not less than 8 ft (2.4 m) on center.

8.12.4 Deflector Position (Early Suppression Fast-Response Sprinklers).

8.12.4.1 Distance Below Ceilings.

8.12.4.1.1 Pendent sprinklers with a nominal K-factor of 14 shall be positioned so that deflectors are a maximum 14 in. (356 mm) and a minimum 6 in. (152 mm) below the ceiling.

8.12.4.1.2 Pendent sprinklers with a nominal K-factor of 25.2 shall be positioned so that deflectors are a maximum 18 in. (457 mm) and a minimum 6 in. (152 mm) below the ceiling.

8.12.4.1.3 Upright sprinklers with a nominal K-factor of 11.2 shall be positioned so that the deflector is 3 in. to 5 in. (76 mm to 127 mm) below the ceiling.

8.12.4.1.4 Upright sprinklers with a nominal K-factor of 14 shall be positioned so that the deflector is 3 in. to 12 in. (76 mm to 304 mm) below the ceiling.

8.12.4.1.5 With obstructed construction, the branch lines shall be permitted to be installed across the beams, but sprinklers shall be located in the bays and not under the beams.

8.12.4.2 Deflector Orientation. Deflectors of sprinklers shall be aligned parallel to ceilings or roofs.

8.12.5 Obstructions to Sprinkler Discharge (Early Suppression Fast-Response Sprinklers).

8.12.5.1 Obstructions at or Near the Ceiling.

8.12.5.1.1 Sprinklers shall be arranged to comply with Table 8.12.5.1.1 and Figure 8.12.5.1.1 for obstructions at the ceiling such as beams, ducts, lights, and top chords of trusses and bar joists.

Table 8.12.5.1.1 Positioning of Sprinklers to Avoid Obstructions to Discharge (ESFR Sprinkler)

Distance from Sprinkler to Side of Obstruction *(A)*	Maximum Allowable Distance of Deflector above Bottom of Obstruction (in.) *(B)*
Less than 1 ft	0
1 ft to less than 1 ft 6 in.	1½
1 ft 6 in. to less than 2 ft	3
2 ft to less than 2 ft 6 in.	5½
2 ft 6 in. to less than 3 ft	8
3 ft to less than 3 ft 6 in.	10
3 ft 6 in. to less than 4 ft	12
4 ft to less than 4 ft 6 in.	15
4 ft 6 in. to less than 5 ft	18
5 ft to less than 5 ft 6 in.	22
5 ft 6 in. to less than 6 ft	26
6 ft	31

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: For *(A)* and *(B)*, refer to Figure 8.12.5.1.1.

8.12.5.1.2 The requirements of 8.12.5.1.1 shall not apply where sprinklers are spaced on opposite sides of obstructions less than 24 in. wide provided the distance from the centerline on the obstructions to the sprinklers does not exceed one-half the allowable distance between sprinklers.

8.12.5.1.3 Sprinklers with a special obstruction allowance shall be installed according to their listing.

8.12.5.2* Isolated Obstructions Below the Elevation of Sprinklers. Sprinklers shall be arranged with respect to obstructions in accordance with one of the following:

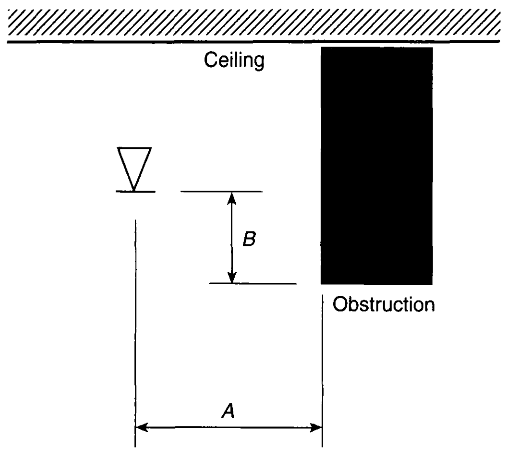


FIGURE 8.12.5.1.1 Positioning of Sprinklers to Avoid Obstructions to Discharge (ESFR Sprinkler).

(1) Sprinklers shall be installed below isolated noncontinuous obstructions that restrict only one sprinkler and are located below the elevation of sprinklers such as light fixtures and unit heaters.
(2) Additional sprinklers shall not be required where the obstruction is 2 ft (0.6 m) or less in width and the sprinkler is located horizontally 1 ft (0.3 m) or greater from the nearest edge of the obstruction.
(3) Additional sprinklers shall not be required where sprinklers are positioned with respect to the bottom of obstructions in accordance with 8.12.5.1.
(4) Additional sprinklers shall not be required where the obstruction is 2 in. (51 mm) or less in width and is located a minimum of 2 ft (0.6 m) below the elevation of the sprinkler deflector or is positioned a minimum of 1 ft (0.3 m) horizontally from the sprinkler.
(5) Sprinklers with a special obstruction allowance shall be installed according to their listing.

8.12.5.3 Continuous Obstructions Below the Sprinklers.

8.12.5.3.1 General Continuous Obstructions. Sprinklers shall be arranged with respect to obstructions in accordance with one of the following:

(1) Sprinklers shall be installed below continuous obstructions or they shall be arranged to comply with Table 8.12.5.1.1 for horizontal obstructions entirely below the elevation of sprinklers that restrict sprinkler discharge pattern for two or more adjacent sprinklers such as ducts, lights, pipes, and conveyors.
(2) Additional sprinklers shall not be required where the obstruction is 2 in. (51 mm) or less in width and is located a minimum of 2 ft (0.6 m) below the elevation of the sprinkler deflector or is positioned a minimum of 1 ft (0.3 m) horizontally from the sprinkler.
(3) Additional sprinklers shall not be required where the obstruction is 1 ft (0.3 m) or less in width and located a minimum of 1 ft (0.3 m) horizontally from the sprinkler.
(4) Additional sprinklers shall not be required where the obstruction is 2 ft (0.6 m) or less in width and located a minimum of 2 ft (0.6 m) horizontally from the sprinkler.
(5) Ceiling sprinklers shall not be required to comply with Table 8.12.5.1.1 where a row of sprinklers is installed under the obstruction.

8.12.5.3.2 Upright Sprinklers.

8.12.5.3.2.1 Upright sprinklers shall be installed on sprigs arranged so that the deflector is a minimum of 7 in. (178 mm) above the top of the sprinkler pipe.

8.12.5.3.2.2 K-11.2 upright sprinklers shall be permitted to be installed on sprigs arranged so that the deflector is a minimum of 7 in. (178 mm) above the top of the sprinkler pipe.

8.12.5.3.3 Bottom Chords of Bar Joists or Open Trusses. ESFR sprinklers shall be positioned a minimum of 1 ft (0.3 m) horizontally from the nearest edge to any bottom chord of a bar joist or open truss.

8.12.5.3.4 Open Gratings. Sprinklers installed under open gratings shall be of the intermediate level/rack storage type or otherwise shielded from the discharge of overhead sprinklers.

8.12.5.3.5 Overhead Doors. Quick response spray sprinklers shall be permitted to be utilized under overhead doors.

8.12.5.3.6 Special Obstruction Allowance. Sprinklers with a special obstruction allowance shall be installed according to their listing.

8.12.6 Clearance to Storage (Early Suppression Fast-Response Sprinklers). The clearance between the deflector and the top of storage shall be 36 in. (914 mm) or greater.

8.13 In-Rack Sprinklers.

8.13.1 System Size. The area protected by a single system of sprinklers in racks shall not exceed 40,000 ft^2 (3716 m^2) of floor area occupied by the racks, including aisles, regardless of the number of levels of in-rack sprinklers.

8.13.2 Type of In-Rack Sprinklers.

8.13.2.1 Sprinklers in racks shall be ordinary-temperature standard-response or quick-response classification with a nominal K-factor of 5.6 or 8.0, pendent or upright.

8.13.2.2 Sprinklers with intermediate- and high-temperature ratings shall be used near heat sources as required by 8.3.2.

8.13.3 In-Rack Sprinkler Water Shields.

8.13.3.1 In-Rack Sprinkler Water Shields for Storage of Class I through IV Commodities. Water shields shall be provided directly above in-rack sprinklers, or listed intermediate level/rack storage sprinklers shall be used where there is more than one level, if not shielded by horizontal barriers. *(See Section C.3.)*

8.13.3.2 In-Rack Sprinkler Water Shields for Plastic Storage. Where in-rack sprinklers are not shielded by horizontal barriers, water shields shall be provided above the sprinklers, or listed intermediate level/rack storage sprinklers shall be used.

8.13.4 Location, Position, and Spacing of In-Rack Sprinklers. See Section 12.3.

8.13.5 Obstructions to In-Rack Sprinkler Discharge. In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements of Section 8.5.

8.14 Special Situations.

8.14.1 Concealed Spaces.

8.14.1.1 Concealed Spaces Requiring Sprinkler Protection. All concealed spaces enclosed wholly or partly by exposed combustible construction shall be protected by sprinklers except in concealed spaces where sprinklers are not required to be installed by 8.14.1.2.1 through 8.14.1.2.15.

8.14.1.2* Concealed Spaces Not Requiring Sprinkler Protection.

8.14.1.2.1 Noncombustible and limited combustible concealed spaces with no combustible loading having no access shall not require sprinkler protection. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.

8.14.1.2.2 Noncombustible and limited combustible concealed spaces with limited access and not permitting occupancy or storage of combustibles shall not require sprinkler protection. The space shall be considered a concealed space even with small openings such as those used as return air for a plenum.

8.14.1.2.3 Concealed spaces formed by studs or joists with less than 6 in. (152 mm) between the inside or near edges of the studs or joists shall not require sprinkler protection. *(See Figure 8.6.4.1.5.1.)*

8.14.1.2.4 Concealed spaces formed by bar joists with less than 6 in. (152 mm) between the roof or floor deck and ceiling shall not require sprinkler protection.

8.14.1.2.5 Concealed spaces formed by ceilings attached directly to or within 6 in. (152 mm) of wood joist construction shall not require sprinkler protection.

8.14.1.2.6* Concealed spaces formed by ceilings attached to composite wood joist construction either directly or onto metal channels not exceeding 1 in. in depth, provided the joist channels are firestopped into volumes each not exceeding 160 ft^3 (4.53 m^3) using materials equivalent to the web construction and at least 3½ in. of batt insulation is installed at the bottom of the joist channels when the ceiling is attached utilizing metal channels, shall not require sprinkler protection.

8.14.1.2.7 Concealed spaces entirely filled with noncombustible insulation shall not require sprinkler protection.

8.14.1.2.8 Concealed spaces within wood joist construction and composite wood joist construction having noncombustible insulation filling the space from the ceiling up to the bottom edge of the joist of the roof or floor deck, provided that in composite wood joist construction the joist channels are firestopped into volumes each not exceeding 160 ft^3 (4.53 m^3) to the full depth of the joist with material equivalent to the web construction, shall not require sprinkler protection.

8.14.1.2.9 Concealed spaces over isolated small rooms not exceeding 55 ft^2 (4.6 m^2) in area shall not require sprinkler protection.

8.14.1.2.10 Concealed spaces where rigid materials are used and the exposed surfaces have a flame spread rating of 25 or less and the materials have been demonstrated not to propagate fire in the form in which they are installed shall not require sprinkler protection.

8.14.1.2.11 Concealed spaces in which the exposed materials are constructed entirely of fire-retardant treated wood as defined by NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials,* shall not require sprinkler protection.

8.14.1.2.12 Noncombustible concealed spaces having exposed combustible insulation where the heat content of the facing and substrate of the insulation material does not exceed 1000 Btu/ft^2 (11,356 kJ/m^2) shall not require sprinkler protection.

8.14.1.2.13 Concealed spaces below insulation that is laid directly on top of or within the ceiling joists in an otherwise sprinklered attic shall not require sprinkler protection.

8.14.1.2.14 Vertical pipe chases under 10 ft^2 (0.93 m^2), where provided that in multifloor buildings the chases are fire stopped at each floor using materials equivalent to the floor construction, and where such pipe chases shall contain no sources of ignition, piping shall be noncombustible, and pipe penetrations at each floor shall be properly sealed and shall not require sprinkler protection.

8.14.1.2.15 Exterior columns under 10 ft^2 in area formed by studs or wood joist, supporting exterior canopies that are fully protected with a sprinkler system, shall not require sprinkler protection.

8.14.1.3 Concealed Space Design Requirements. Sprinklers in concealed spaces having no access for storage or other use shall be installed in accordance with the requirements for light hazard occupancy.

8.14.1.4 Heat Producing Devices with Composite Wood Joist Construction. Where heat-producing devices such as furnaces or process equipment are located in the joist channels above a ceiling attached directly to the underside of composite wood joist construction that would not otherwise require sprinkler protection of the spaces, the joist channel containing the heat-producing devices shall be sprinklered by installing sprinklers in each joist channel, on each side, adjacent to the heat-producing device.

8.14.1.5 Localized Protection of Exposed Combustible Construction or Exposed Combustibles. In concealed spaces having exposed combustible construction, or containing exposed combustibles, in localized areas, the combustibles shall be protected as follows:

(1) If the exposed combustibles are in the vertical partitions or walls around all or a portion of the enclosure, a single row of sprinklers spaced not over 12 ft (3.7 m) apart nor more than 6 ft (1.8 m) from the inside of the partition shall be permitted to protect the surface. The first and last sprinklers in such a row shall not be over 5 ft (1.5 m) from the ends of the partitions.
(2) If the exposed combustibles are in the horizontal plane, the area of the combustibles shall be permitted to be protected with sprinklers on a light hazard spacing. Additional sprinklers shall be installed no more than 6 ft (1.8 m) outside the outline of the area and not more than 12 ft (3.7 m) on center along the outline. When the outline returns to a wall or other obstruction, the last sprinkler shall not be more than 6 ft (1.8 m) from the wall or obstruction.

8.14.1.6* Sprinklers used in horizontal combustible concealed spaces (with a slope not exceeding 2 in 12) having a combustible upper surface where the assembly or supporting members channel heat and where the depth of the space is less than 36 in. from deck to deck or with double wood joist construction with a maximum of 36 in. between the top of the bottom joist and the bottom of the upper joist shall be listed for such use.

8.14.2 Vertical Shafts.

8.14.2.1 General. Unless the requirements of 8.14.2.1.1 or 8.14.2.1.2 are met, one sprinkler shall be installed at the top of shafts.

8.14.2.1.1 Noncombustible or limited-combustible, nonaccessible vertical duct shafts shall not require sprinkler protection.

8.14.2.1.2 Noncombustible or limited-combustible, nonaccessible vertical electrical or mechanical shafts shall not require sprinkler protection.

8.14.2.2* Shafts with Combustible Surfaces.

8.14.2.2.1 Where vertical shafts have combustible surfaces, one sprinkler shall be installed at each alternate floor level.

8.14.2.2.2 Where a shaft having combustible surfaces is trapped, an additional sprinkler shall be installed at the top of each trapped section.

8.14.2.3 Accessible Shafts with Noncombustible Surfaces. Where accessible vertical shafts have noncombustible surfaces, one sprinkler shall be installed near the bottom.

8.14.3 Stairways.

8.14.3.1 Combustible Construction. Sprinklers shall be installed beneath all stairways of combustible construction.

8.14.3.2 Noncombustible Construction.

8.14.3.2.1 In noncombustible stair shafts with noncombustible stairs, sprinklers shall be installed at the top of the shaft and under the first landing above the bottom of the shaft.

8.14.3.2.2 Where noncombustible stair shafts are divided by walls or doors, sprinklers shall be provided on each side of the separation.

8.14.3.2.3 Sprinklers shall be installed beneath landings or stairways where the area beneath is used for storage.

8.14.3.3* Stairs Serving Two or More Fire Divisions. Sprinklers shall be installed in the stair shaft at each floor landing where two or more doors open from that landing into separate fire divisions.

8.14.4* Vertical Openings.

8.14.4.1 General. Unless the requirements of 8.14.4.4 or 8.14.4.5 are met, where moving stairways, staircases, or similar floor openings are unenclosed, the floor openings involved shall be protected by closely spaced sprinklers in combination with draft stops in accordance with 8.14.4.2 and 8.14.4.3.

8.14.4.2 Draft Stops. Draft stops shall meet all of the following:

(1) The draft stops shall be located immediately adjacent to the opening.
(2) The draft stops shall be at least 18 in. (457 mm) deep.
(3) The draft stops shall be of noncombustible or limited-combustible material that will stay in place before and during sprinkler operation.

8.14.4.3 Sprinklers.

8.14.4.3.1 Sprinklers shall be spaced not more than 6 ft (1.8 m) apart and placed 6 in. to 12 in. (152 mm to 305 mm) from the draft stop on the side away from the opening.

8.14.4.3.2 Where sprinklers are closer than 6 ft (1.8 m), cross baffles shall be provided in accordance with 8.6.3.4.2.

8.14.4.4 Large Openings. Closely spaced sprinklers and draft stops are not required around large openings such as those found in shopping malls, atrium buildings, and similar structures where all adjoining levels and spaces are protected by automatic sprinklers in accordance with this standard and where the openings have all horizontal dimensions between opposite edges of 20 ft (6 m) or greater and an area of 1000 ft^2 (93 m^2) or greater.

8.14.4.5 Convenience Openings in Individual Dwelling Units. Draft stops and closely spaced sprinklers are not required for convenience openings within individual dwelling units that meet all of the following criteria:

(1) Such openings shall connect a maximum of two adjacent stories (pierce one floor only).
(2)*Such openings shall be separated from unprotected vertical openings serving other floors by a barrier with a fire resistance rating equal to that required for enclosure of floor openings by NFPA *101*®, *Life Safety Code*®.
(3) Such openings shall be separate from corridors.
(4) Such openings shall not serve as a required means of egress, although they can serve as a required means of escape.

8.14.5 Elevator Hoistways and Machine Rooms.

8.14.5.1* Sidewall spray sprinklers shall be installed at the bottom of each elevator hoistway not more than 2 ft (0.61 m) above the floor of the pit.

8.14.5.2 The sprinkler required at the bottom of the elevator hoistway by 8.14.5.1 shall not be required for enclosed, noncombustible elevator shafts that do not contain combustible hydraulic fluids.

8.14.5.3* Automatic sprinklers in elevator machine rooms or at the tops of hoistways shall be of ordinary- or intermediate-temperature rating.

8.14.5.4* Upright or pendent spray sprinklers shall be installed at the top of elevator hoistways.

8.14.5.5 The sprinkler required at the top of the elevator hoistway by 8.14.5.4 shall not be required where the hoistway for passenger elevators is noncombustible and the car enclosure materials meet the requirements of ASME A17.1, *Safety Code for Elevators and Escalators.*

8.14.6 Spaces Under Ground Floors, Exterior Docks, and Platforms.

8.14.6.1 Unless the requirements of 8.14.6.2 are met, sprinklers shall be installed in spaces under all combustible ground floors, exterior docks, and platforms.

8.14.6.2 Sprinklers shall be permitted to be omitted from spaces under ground floors, exterior docks, and platforms where all of the following conditions prevail:

(1) The space is not accessible for storage purposes and is protected against accumulation of wind-borne debris.
(2) The space contains no equipment such as conveyors or fuel-fired heating units.
(3) The floor over the space is of tight construction.
(4) No combustible or flammable liquids or materials that under fire conditions would convert into combustible or flammable liquids are processed, handled, or stored on the floor above the space.

8.14.7* Exterior Roofs or Canopies.

8.14.7.1* Unless the requirements of 8.14.7.2 or 8.14.7.3 are met, sprinklers shall be installed under exterior roofs or canopies exceeding 4 ft (1.2 m) in width.

8.14.7.2 Sprinklers shall be permitted to be omitted where the canopy or roof is of noncombustible or limited combustible construction.

8.14.7.3 Sprinklers shall be permitted to be omitted from exterior exit corridors when the exterior walls of the corridor are at least 50 percent open and when the corridor is entirely of noncombustible construction.

8.14.7.4* Sprinklers shall be installed under roofs or canopies over areas where combustibles are stored and handled.

8.14.8 Dwelling Units.

8.14.8.1 Bathrooms.

8.14.8.1.1 Unless sprinklers are required by 8.14.8.1.2 or 8.14.8.1.3, sprinklers shall not be required in bathrooms that are located within dwelling units, that do not exceed 55 ft^2 (5.1 m^2) in area, and that have walls and ceilings of noncombustible or limited-combustible materials with a 15-minute thermal barrier rating including the walls and ceilings behind fixtures.

8.14.8.1.2 Sprinklers shall be required in bathrooms of nursing homes, as defined in NFPA *101, Life Safety Code.*

8.14.8.1.3 Sprinklers shall be required in bathrooms opening directly onto public corridors or exitways.

8.14.8.2* Closets and Pantries. Sprinklers are not required in clothes closets, linen closets, and pantries within dwelling units in hotels and motels where the area of the space does not exceed 24 ft^2 (2.2 m^2), the least dimension does not exceed 3 ft (0.9 m), and the walls and ceilings are surfaced with noncombustible or limited-combustible materials.

8.14.9 Library Stack Rooms. Sprinklers shall be installed in accordance with one of the following:

(1) Sprinklers shall be permitted to be installed without regard to aisles where there is 18 in. (457 mm) or more clearance between sprinkler deflectors and tops of racks.
(2) Where the 18 in. (457 mm) clearance between sprinkler deflectors and tops of racks cannot be maintained, sprinklers shall be installed in every aisle and at every tier of stacks with distance between sprinklers along aisles not to exceed 12 ft (3.7 m) in accordance with Figure 8.14.9(a).
(3) Where the 18 in. (457 mm) clearance between sprinkler deflectors and tops of racks cannot be maintained and where vertical shelf dividers are incomplete and allow water distribution to adjacent aisles, sprinklers shall be permitted to be omitted in alternate aisles on each tier, and where ventilation openings are also provided in tier floors, sprinklers shall be staggered vertically in accordance with Figure 8.14.9(b).

8.14.10 Electrical Equipment.

8.14.10.1 Unless the requirements of 8.14.10.3 are met, sprinkler protection shall be required in electrical equipment rooms.

8.14.10.2 Hoods or shields installed to protect important electrical equipment from sprinkler discharge shall be noncombustible.

8.14.10.3 Sprinklers shall not be required in electrical equipment rooms where all of the following conditions are met:

(1) The room is dedicated to electrical equipment only.
(2) Only dry-type electrical equipment is used.
(3) Equipment is installed in a 2-hour fire-rated enclosure including protection for penetrations.
(4) No combustible storage is permitted to be stored in the room.

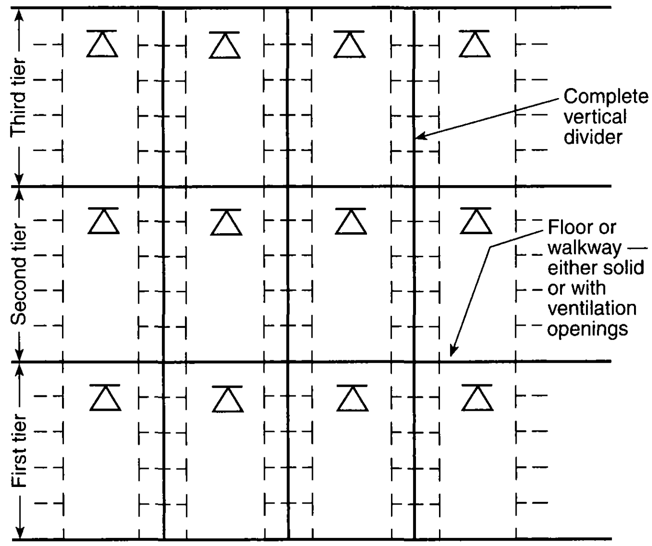


FIGURE 8.14.9(a) Sprinklers in Multitier Library Bookstacks with Complete Vertical Dividers.

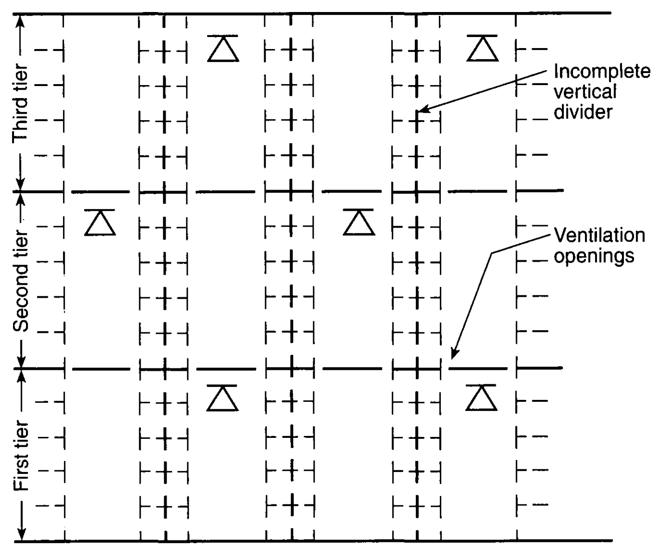


FIGURE 8.14.9(b) Sprinklers in Multitier Library Bookstacks with Incomplete Vertical Dividers.

8.14.11* Industrial Ovens and Furnaces.

8.14.12* Open-Grid Ceilings. Open-grid ceilings shall only be installed beneath sprinklers where one of the following is met:

(1) Open-grid ceilings in which the openings are ¼ in. (6.4 mm) or larger in the least dimension, where the thickness or depth of the material does not exceed the least dimension of the opening, and where such openings constitute 70 percent of the area of the ceiling material. The spacing of the sprinklers over the open-grid ceiling shall then comply with the following:
   (a) In light hazard occupancies where sprinkler spacing (either spray or old-style sprinklers) is less than 10 ft × 10 ft (3 m × 3 m), a minimum clearance of at least 18 in. (457 mm) shall be provided between

the sprinkler deflectors and the upper surface of the open-grid ceiling. Where spacing is greater than 10 ft × 10 ft (3 m × 3 m) but less than 10 ft × 12 ft (3 m × 3.7 m), a clearance of at least 24 in. (610 mm) shall be provided from spray sprinklers and at least 36 in. (914 mm) from old-style sprinklers. Where spacing is greater than 10 ft × 12 ft (3 m × 3.7 m), a clearance of at least 48 in. (1219 mm) shall be provided.

(b) In ordinary hazard occupancies, open-grid ceilings shall be permitted to be installed beneath spray sprinklers only. Where sprinkler spacing is less than 10 ft × 10 ft (3 m × 3 m), a minimum clearance of at least 24 in. (610 mm) shall be provided between the sprinkler deflectors and the upper surface of the open-grid ceiling. Where spacing is greater than 10 ft × 10 ft (3 m × 3 m), a clearance of at least 36 in. (914 mm) shall be provided.

(2) Other types of open-grid ceilings shall be permitted to be installed beneath sprinklers where they are listed for such service and are installed in accordance with instructions contained in each package of ceiling material.

8.14.13 Drop-Out Ceilings.

8.14.13.1 Drop-out ceilings shall be permitted to be installed beneath sprinklers where ceilings are listed for that service and are installed in accordance with their listings.

8.14.13.2 Special sprinklers shall not be installed above drop-out ceilings unless specifically listed for this purpose.

8.14.13.3 Drop-out ceilings shall not be considered ceilings within the context of this standard.

8.14.13.4* Piping installed above drop-out ceilings shall not be considered concealed piping.

8.14.13.5* Sprinklers shall not be installed beneath drop-out ceilings.

8.14.14 Old-Style Sprinklers.

8.14.14.1 Unless required by 8.14.14.2 or 8.14.14.3, old-style sprinklers shall not be used in a new installation.

8.14.14.2* Old-style sprinklers shall be installed in fur storage vaults.

8.14.14.3 Use of old-style sprinklers shall be permitted where construction features or other special situations require unique water distribution.

8.14.15 Stages.

8.14.15.1 Sprinklers shall be installed under the roof at the ceiling, in spaces under the stage either containing combustible materials or constructed of combustible materials, and in all adjacent spaces and dressing rooms, storerooms, and workshops.

8.14.15.2 Where proscenium opening protection is required, a deluge system shall be provided with open sprinklers located not more than 3 ft (0.9 m) away from the stage side of the proscenium arch and spaced up to a maximum of 6 ft (1.8 m) on center. *(See Chapter 11 for design criteria.)*

8.14.16 Provision for Flushing Systems.

8.14.16.1 All sprinkler systems shall be arranged for flushing.

8.14.16.2 Readily removable fittings shall be provided at the end of all cross mains.

8.14.16.3 All cross mains shall terminate in 1¼ in. (31.8 mm) or larger pipe.

8.14.16.4 All branch lines on gridded systems shall be arranged to facilitate flushing.

8.14.17 Stair Towers. Stairs, towers, or other construction with incomplete floors, if piped on independent risers, shall be treated as one area with reference to pipe sizes.

8.14.18 Return Bends.

8.14.18.1 Unless the requirements of 8.14.18.3 or 8.14.18.4 are met, return bends shall be used where pendent sprinklers are supplied from a raw water source, a mill pond, or open-top reservoirs.

8.14.18.2 Return bends shall be connected to the top of branch lines in order to avoid accumulation of sediment in the drop nipples in accordance with Figure 8.14.18.2.

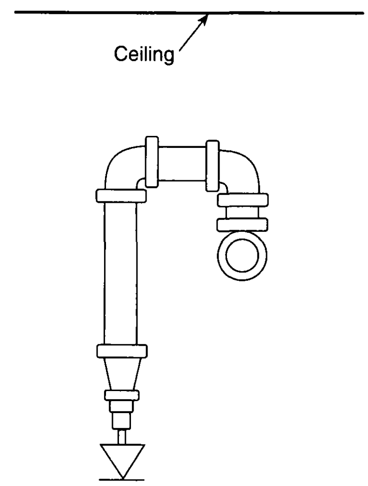


FIGURE 8.14.18.2 Return Bend Arrangement.

8.14.18.3 Return bends shall not be required for deluge systems.

8.14.18.4 Return bends shall not be required where dry-pendent sprinklers are used.

8.14.19 Piping to Sprinklers Below Ceilings.

8.14.19.1* In new installations expected to supply sprinklers below a ceiling, minimum 1-in. (25.4-mm) outlets shall be provided.

8.14.19.2 The 1-in. (25.4-mm) outlets required by 8.14.19.1 shall be permitted to utilize hexagonal bushings to accommodate temporary sprinklers and shall be removed with the temporary sprinklers when the permanent ceiling sprinklers are installed.

8.14.19.3 Revamping of Pipe Schedule Systems.

8.14.19.3.1 When pipe schedule systems are revamped, a nipple not exceeding 4 in. (102 mm) in length shall be permitted to be installed in the branch line fitting.

8.14.19.3.2 All piping other than the nipple permitted in 8.14.19.3.1 and 8.14.19.3.3 shall be a minimum of 1 in. (25.4 mm) in diameter in accordance with Figure 8.14.19.3.2.

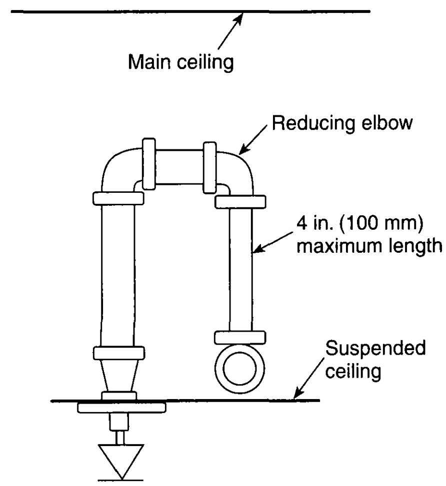


FIGURE 8.14.19.3.2 Nipple and Reducing Elbow Supplying Sprinkler Below Ceiling.

8.14.19.3.3 When it is necessary to pipe two new ceiling sprinklers from an existing outlet in an overhead system, the use of a nipple not exceeding 4 in. (102 mm) in length and of the same pipe thread size as the existing outlet shall be permitted, provided that a hydraulic calculation verifies that the design flow rate will be achieved in accordance with Figure 8.14.19.3.3.

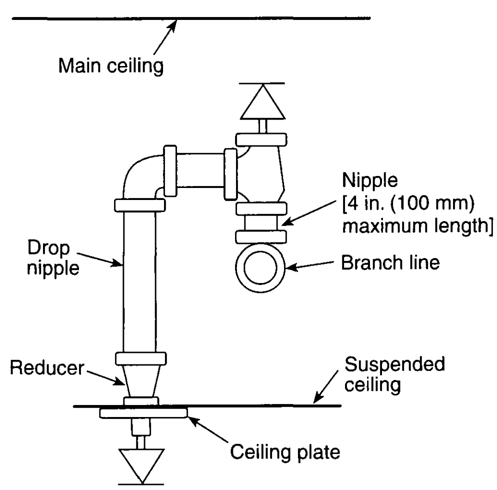


FIGURE 8.14.19.3.3 Sprinklers in Concealed Space and Below Ceiling.

8.14.19.3.4 The use of pipe nipples less than 1 in. (25.4 mm) in diameter shall not be permitted in areas subject to earthquakes.

8.14.19.4 Revamping of Hydraulic Design Systems.

8.14.19.4.1 When hydraulically designed systems are revamped, any existing bushing shall be removed and a nipple not exceeding 4 in. (102 mm) in length shall be permitted to be installed in the branch line fitting.

8.14.19.4.2 Calculations shall be provided to verify that the system design flow rate will be achieved.

8.14.19.4.3 When it is necessary to pipe two new ceiling sprinklers from an existing outlet in an overhead system, any bushings shall be removed and the use of a nipple not exceeding 4 in. (102 mm) in length and of the same pipe thread size as the existing outlet shall be permitted, provided that a hydraulic calculation verifies that the design flow rate will be achieved.

8.14.19.4.4 The use of pipe nipples less than 1 in. (25.4 mm) in diameter is not permitted in areas subject to earthquakes.

8.14.20 Dry Pipe Underground.

8.14.20.1 Where necessary to place pipe that will be under air pressure underground, the pipe shall be protected against corrosion.

8.14.20.2 Unprotected cast-iron or ductile-iron pipe shall be permitted where joined with a gasketed joint listed for air service underground.

8.14.21* System Subdivision. Where individual floor/zone control valves are not provided, a flanged joint or mechanical coupling shall be used at the riser at each floor for connections to piping serving floor areas in excess of 5000 ft^2 (465 m^2).

8.14.22 Spaces Above Ceilings.

8.14.22.1 Where spaces have ceilings that are lower than the rest of the area, the space above this lower ceiling shall be sprinklered unless it complies with the rules of 8.14.1.2 for allowable unsprinklered concealed spaces.

8.14.22.2 Where the space above a drop ceiling is sprinklered, the sprinkler system shall conform to the rules of 12.1.13.

8.15 Piping Installation.

8.15.1 Valves.

8.15.1.1* Control Valves.

8.15.1.1.1* General.

8.15.1.1.1.1 Each sprinkler system shall be provided with a listed indicating valve in an accessible location, so located as to control all automatic sources of water supply.

8.15.1.1.1.2 At least one listed indicating valve shall be installed in each source of water supply.

8.15.1.1.1.3 The requirements of 8.15.1.1.1.2 shall not apply to the fire department connection, and there shall be no shutoff valve in the fire department connection.

8.15.1.1.2* Supervision.

8.15.1.1.2.1 Valves on connections to water supplies, sectional control and isolation valves, and other valves in supply pipes to sprinklers and other fixed water-based fire suppression systems shall be supervised by one of the following methods:

(1) Central station, proprietary, or remote station signaling service
(2) Local signaling service that will cause the sounding of an audible signal at a constantly attended point
(3) Valves locked in the correct position
(4) Valves located within fenced enclosures under the control of the owner, sealed in the open position, and inspected weekly as part of an approved procedure

8.15.1.1.2.2 Floor control valves in high-rise buildings and valves controlling flow to sprinklers in circulating closed loop systems shall comply with 8.15.1.1.2.1(1) or 8.15.1.1.2.1(2).

8.15.1.1.2.3 The requirements of 8.15.1.1.2.1 shall not apply to underground gate valves with roadway boxes.

8.15.1.1.2.4 Where control valves are installed overhead, they shall be positioned so that the indicating feature is visible from the floor below.

8.15.1.1.3 Check Valves.

8.15.1.1.3.1 Where there is more than one source of water supply, a check valve shall be installed in each connection.

8.15.1.1.3.2 A listed backflow prevention device shall be considered a check valve, and an additional check valve shall not be required.

8.15.1.1.3.3 Where cushion tanks are used with automatic fire pumps, no check valve is required in the cushion tank connection.

8.15.1.1.3.4 Check valves shall be installed in a vertical or horizontal position in accordance with their listing.

8.15.1.1.3.5* Where a single wet pipe sprinkler system is equipped with a fire department connection, the alarm valve is considered a check valve, and an additional check valve shall not be required.

8.15.1.1.4* Control Valves with Check Valves.

8.15.1.1.4.1 In a connection serving as one source of supply, listed indicating valves or post-indicator valves shall be installed on both sides of all check valves required in 8.15.1.1.3.

8.15.1.1.4.2 The requirements of 8.15.1.1.4.1 shall not apply to the check valve located in the fire department connection piping, and there shall be no control valves in the fire department connection piping.

8.15.1.1.4.3 The requirements of 8.15.1.1.4.1 shall not apply, where the city connection serves as the only automatic source of supply to a wet pipe sprinkler system, a control valve is not required on the system side of the check valve or the alarm check valve.

8.15.1.1.5* Gravity Tanks.

8.15.1.1.5.1 Where a gravity tank is located on a tower in the yard, the control valve on the tank side of the check valve shall be an outside screw and yoke or listed indicating valve; the other shall be either an outside screw and yoke, a listed indicating valve, or a listed valve having a post-type indicator.

8.15.1.1.5.2 Where a gravity tank is located on a building, both control valves shall be outside screw and yoke or listed indicating valves, and all fittings inside the building except the drain tee and heater connections shall be under the control of a listed valve.

8.15.1.1.6* Pumps. When a pump is located in a combustible pump house or exposed to danger from fire or falling walls, or when a tank discharges into a private fire service main fed by another supply, either the check valve in the connection shall be located in a pit or the control valve shall be of the post-indicator type located a safe distance outside buildings.

8.15.1.1.7* Control Valve Accessibility. All control valves shall be located where readily accessible and free of obstructions.

8.15.1.1.8 Control Valve Identification. Identification signs shall be provided at each valve to indicate its function and what it controls.

8.15.1.2 Pressure-Reducing Valves.

8.15.1.2.1 In portions of systems where all components are not listed for pressure greater than 175 psi (12.1 bar) and the potential exists for normal (nonfire condition) water pressure in excess of 175 psi (12.1 bar), a listed pressure-reducing valve shall be installed and set for an outlet pressure not exceeding 165 psi (2.4 bar) at the maximum inlet pressure.

8.15.1.2.2 Pressure gauges shall be installed on the inlet and outlet sides of each pressure-reducing valve.

8.15.1.2.3* A relief valve of not less than ½ in. (13 mm) in size shall be provided on the discharge side of the pressure-reducing valve set to operate at a pressure not exceeding 175 psi (12.1 bar).

8.15.1.2.4 A listed indicating valve shall be provided on the inlet side of each pressure-reducing valve, unless the pressure-reducing valve meets the listing requirements for use as an indicating valve.

8.15.1.2.5 Means shall be provided downstream of all pressure-reducing valves for flow tests at sprinkler system demand.

8.15.1.3* Post-Indicator Valves.

8.15.1.3.1 Post-indicator valves shall be set so that the top of the post will be 36 in. (0.9 m) above the final grade.

8.15.1.3.2 Post-indicator valves shall be properly protected against mechanical damage where needed.

8.15.1.4 Valves in Pits.

8.15.1.4.1 General. Where it is impractical to provide a post-indicator valve, valves shall be permitted to be placed in pits with permission of the authority having jurisdiction.

8.15.1.4.2* Valve Pit Construction.

8.15.1.4.2.1 When used, valve pits shall be of adequate size and readily accessible for inspection, operation, testing, maintenance, and removal of equipment contained therein.

8.15.1.4.2.2 Valve pits shall be constructed and arranged to properly protect the installed equipment from movement of earth, freezing, and accumulation of water.

8.15.1.4.2.3 Poured-in-place or precast concrete, with or without reinforcement, or brick (all depending upon soil conditions and size of pit) shall be appropriate materials for construction of valve pits.

8.15.1.4.2.4 Other approved materials shall be permitted to be used for valve pit construction.

8.15.1.4.2.5 Where the water table is low and the soil is porous, crushed stone or gravel shall be permitted to be used for the floor of the pit. *[See Figure A.8.16.2(b) for a suggested arrangement.]*

8.15.1.4.2.6 Valve pits located at or near the base of the riser of an elevated tank shall be designed in accordance with Chapter 9 of NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

8.15.1.4.3 Valve Pit Marking. The location of the valve shall be clearly marked, and the cover of the pit shall be kept free of obstructions.

8.15.1.5 Sectional Valves.

8.15.1.5.1 Large private fire service main systems shall have sectional controlling valves at appropriate points in order to permit sectionalizing the system in the event of a break or for the making of repairs or extensions.

8.15.1.5.2 A valve shall be provided on each bank where a main crosses water and outside the building foundation(s) where the main or section of main runs under a building.

8.15.1.6* In-Rack Sprinkler System Control Valves.

8.15.1.6.1 Unless the requirements of 8.15.1.6.2 or 8.15.1.6.3 are met, where sprinklers are installed in racks, separate indicating control valves and drains shall be provided and arranged so that ceiling and in-rack sprinklers can be controlled independently.

8.15.1.6.2 Installation of 20 or fewer in-rack sprinklers supplied by any one ceiling sprinkler system shall not require a separate indicating control valve.

8.15.1.6.3 The separate indicating valves shall be permitted to be arranged as sectional control valves where the racks occupy only a portion of the area protected by the ceiling sprinklers.

8.15.2 Drainage.

8.15.2.1* General. All sprinkler pipe and fittings shall be so installed that the system can be drained.

8.15.2.2 Wet Pipe Systems.

8.15.2.2.1 On wet pipe systems, sprinkler pipes shall be permitted to be installed level.

8.15.2.2.2 Trapped piping shall be drained in accordance with 8.15.2.5.

8.15.2.3 Dry Pipe and Preaction Systems. Piping shall be pitched to drain as stated in 8.15.2.3.1 through 8.15.2.3.4.

8.15.2.3.1 Dry Pipe Systems in Non-Refrigerated Areas. In dry pipe systems branch lines shall be pitched at least ½ in. per 10 ft (4 mm/m) and mains shall be pitched at least ¼ in. per 10 ft (2 mm/m).

8.15.2.3.2 Preaction Systems Subject to Freezing. In preaction systems where a portion of the piping is subject to freezing, branch lines shall be pitched at least ½ in. per 10 ft (4 mm/m) and mains shall be pitched at least ¼ in. per 10 ft (2 mm/m).

8.15.2.3.3 Preaction Systems Not Subject to Freezing. Preaction systems located entirely in areas not subject to freezing shall not be required to be pitched.

8.15.2.3.4 Dry Pipe and Preaction Systems in Refrigerated Areas. Branch lines shall be pitched at least ½ in. per 10 ft (4 mm/m), and mains shall be pitched at least ½ in. per 10 ft (4 mm/m) in refrigerated areas.

8.15.2.4* System, Main Drain, or Sectional Drain Connections. See Figure 8.15.2.4.

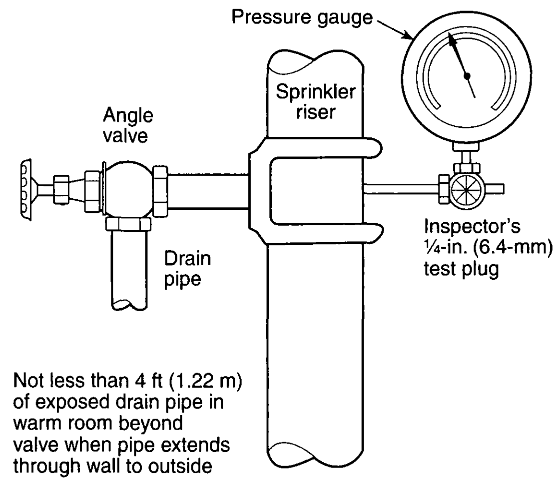


FIGURE 8.15.2.4 Drain Connection for System Riser.

8.15.2.4.1 Provisions shall be made to properly drain all parts of the system.

8.15.2.4.2 Drain connections for systems supply risers and mains shall be sized as shown in Table 8.15.2.4.2.

Table 8.15.2.4.2 Drain Size

Riser or Main Size	Size of Drain Connection
Up to 2 in.	¾ in. or larger
2½ in., 3 in., 3½ in.	1¼ in. or larger
4 in. and larger	2 in. only

For SI units, 1 in. = 25.4 mm.

8.15.2.4.3 Where an interior sectional or floor control valve(s) is provided, it shall be provided with a drain connection having a minimum size as shown in Table 8.15.2.4.2 to drain that portion of the system controlled by the sectional valve.

8.15.2.4.4 Drains shall discharge outside or to a drain connection. *[See Figure A.8.16.4.2(b).]*

8.15.2.4.5 For those drains serving pressure-reducing valves, the drain, drain connection, and all other downstream drain piping shall be sized to permit a flow of at least the greatest system demand supplied by the pressure-reducing valve.

8.15.2.4.6 The test connections required by 8.16.4.1 shall be permitted to be used as main drain connections.

8.15.2.4.7 Where drain connections for floor control valves are tied into a common drain riser, the drain riser shall be one pipe size larger than the largest size drain connection tying into it.

8.15.2.5 Auxiliary Drains.

8.15.2.5.1 Auxiliary drains shall be provided where a change in piping direction prevents drainage of system piping through the main drain valve.

8.15.2.5.2 Auxiliary Drains for Wet Pipe Systems and Preaction Systems in Areas Not Subject to Freezing.

8.15.2.5.2.1* Where the capacity of isolated trapped sections of pipe is 50 gal (189 L) or more, the auxiliary drain shall consist of a valve not smaller than 1 in. (25.4 mm), piped to an accessible location.

8.15.2.5.2.2 Where the capacity of isolated trapped sections of pipe is more than 5 gal (18.9 L) and less than 50 gal (189 L), the auxiliary drain shall consist of a valve ¾ in. (19 mm) or larger and a plug or a nipple and cap.

8.15.2.5.2.3 Where the capacity of trapped sections of pipes in wet systems is less than 5 gal (18.9 L), one of the following arrangements shall be provided:

(1) An auxiliary drain shall consist of a nipple and cap or plug not less than ½ in. (12 mm) in size.

(2) An auxiliary drain shall not be required for trapped sections less than 5 gal (18.9 L) where the system piping can be drained by removing a single pendent sprinkler.
(3) Where flexible couplings or other easily separated connections are used, the nipple and cap or plug shall be permitted to be omitted.

8.15.2.5.2.4 Tie-in drains shall not be required on wet pipe systems and preaction systems protecting non-freezing environments.

8.15.2.5.3 Auxiliary Drains for Dry Pipe Systems and Preaction Systems in Areas Subject to Freezing.

8.15.2.5.3.1 Where the capacity of trapped sections of pipe is less than 5 gal (18.9 L), the auxiliary drain shall consist of a valve not smaller than ½ in. (12 mm) and a plug or a nipple and cap.

8.15.2.5.3.2 Auxiliary drains are not for pipe drops supplying dry-pendent sprinklers installed in accordance with 7.2.2.

8.15.2.5.3.3 Where the capacity of isolated trapped sections of system piping is more than 5 gal (18.9 L), the auxiliary drain shall consist of two 1-in. (25.4-mm) valves and one 2-in. × 12-in. (51-mm × 305-mm) condensate nipple or equivalent, accessibly located in accordance with Figure 8.15.2.5.3.3.

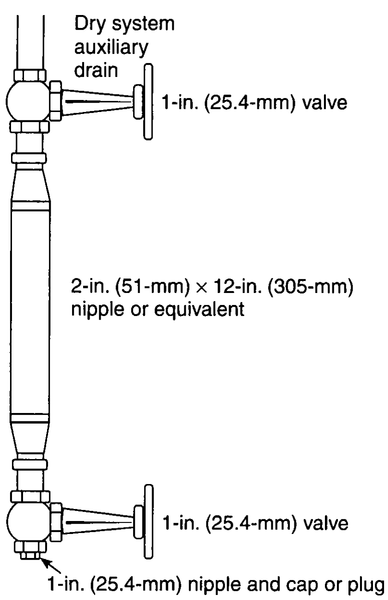


FIGURE 8.15.2.5.3.3 Dry System Auxiliary Drain.

8.15.2.5.3.4 Tie-in drains shall be provided for multiple adjacent trapped branch pipes and shall be only 1 in. (25.4 mm). Tie-in drain lines shall be pitched a minimum of ½ in. per 10 ft (4 mm/m).

8.15.2.6 Discharge of Drain Valves.

8.15.2.6.1* Direct interconnections shall not be made between sprinkler drains and sewers.

8.15.2.6.2 The drain discharge shall conform to any health or water department regulations.

8.15.2.6.3 Where drain pipes are buried underground, approved corrosion-resistant pipe shall be used.

8.15.2.6.4 Drain pipes shall not terminate in blind spaces under the building.

8.15.2.6.5 Where exposed to the atmosphere, drain pipes shall be fitted with a turned-down elbow.

8.15.2.6.6 Drain pipes shall be arranged to avoid exposing any part of the sprinkler system to freezing conditions.

8.15.3 Protection of Piping.

8.15.3.1 Protection of Piping Against Freezing.

8.15.3.1.1 Unless the requirements of 8.15.3.1.2 are met, where portions of systems are subject to freezing and temperatures cannot reliably be maintained at or above 40°F (4°C), sprinklers shall be installed as a dry pipe or preaction system.

8.15.3.1.2 Small unheated areas are permitted to be protected by antifreeze systems or by other systems specifically listed for this purpose.

8.15.3.1.3* Where aboveground water-filled supply pipes, risers, system risers, or feed mains pass through open areas, cold rooms, passageways, or other areas exposed to freezing temperatures, the pipe shall be protected against freezing by insulating coverings, frostproof casings, or other reliable means capable of maintaining a minimum temperature between 40°F (4°C) and 120°F (48.9°C).

8.15.3.2 Protection of Piping Against Corrosion.

8.15.3.2.1* Where corrosive conditions are known to exist due to moisture or fumes from corrosive chemicals or both, special types of fittings, pipes, and hangers that resist corrosion shall be used, or a protective coating shall be applied to all unprotected exposed surfaces of the sprinkler system.

8.15.3.2.2 Where water supplies are known to have unusual corrosive properties and threaded or cut-groove steel pipe is to be used, wall thickness shall be in accordance with Schedule 30 [in sizes 8 in. (200 mm) or larger] or Schedule 40 [in sizes less than 8 in. (200 mm)].

8.15.3.2.3 Where corrosive conditions exist or piping is exposed to the weather, corrosion-resistant types of pipe, fittings, and hangers or protective corrosion-resistant coatings shall be used.

8.15.3.2.4 Where steel pipe is used underground, the pipe shall be protected against corrosion.

8.15.3.3 Protection of Piping in Hazardous Areas.

8.15.3.3.1 Private service main aboveground piping shall not pass through hazardous areas and shall be located so that it is protected from mechanical and fire damage.

8.15.3.3.2 Private service main aboveground piping shall be permitted to be located in hazardous areas protected by an automatic sprinkler system.

8.15.4 Protection of Risers Subject to Mechanical Damage. Sprinkler risers subject to mechanical damage shall be protected by steel posts, concrete barriers, or other approved means.

8.16 System Attachments.

8.16.1* Sprinkler Alarms/Waterflow Alarms.

8.16.1.1 Local Waterflow Alarms. Local waterflow alarms shall be provided on all sprinkler systems having more than 20 sprinklers.

8.16.1.2 Retarding Devices.

8.16.1.2.1 On each alarm check valve used under conditions of variable water pressure, a retarding device shall be installed.

8.16.1.2.2 Valves shall be provided in the connections to retarding devices to permit repair or removal without shutting off sprinklers; these valves shall be so arranged that they can be locked or sealed in the open position.

8.16.1.3 Alarm Bypass Test Connections.

8.16.1.3.1 Alarm, dry pipe, preaction, and deluge valves shall be fitted with an alarm bypass test connection for an electric alarm switch, water motor gong, or both.

8.16.1.3.2 The alarm bypass test connection for alarm, dry pipe, preaction, and deluge valves shall be made on the water supply side of the system and provided with a control valve and drain for the alarm piping.

8.16.1.3.3 The alarm bypass test connection for alarm valves at the riser shall be permitted to be made on the system side of an alarm valve.

8.16.1.3.4 A check valve shall be installed in the pipe connection from the intermediate chamber of a dry pipe valve.

8.16.1.4 Indicating Control Valves.

8.16.1.4.1 An indicating control valve shall be installed in the connection to pressure-type contactors or water motor-operated alarm devices.

8.16.1.4.2 Such valves shall be sealed, locked, or electrically supervised in the open position.

8.16.1.4.3 The control valve for the retarding chamber on alarm check valves shall be accepted as complying with the requirements of 8.16.1.4.

8.16.1.5* Attachments — Mechanically Operated.

8.16.1.5.1 For all types of sprinkler systems employing water motor-operated alarms, a listed ¾-in. (19-mm) strainer shall be installed at the alarm outlet of the waterflow detecting device.

8.16.1.5.2 Where a retarding chamber is used in connection with an alarm valve, the strainer shall be located at the outlet of the retarding chamber unless the retarding chamber is provided with an approved integral strainer in its outlet.

8.16.1.6* Alarm Attachments — High-Rise Buildings. When a fire must be fought internally due to the height of a building, the following additional alarm apparatus shall be provided:

(1) Where each sprinkler system on each floor is equipped with a separate waterflow device, it shall be connected to an alarm system in such a manner that operation of one sprinkler will actuate the alarm system, and the location of the operated flow device shall be indicated on an annunciator and/or register. The annunciator or register shall be located at grade level at the normal point of fire department access, at a constantly attended building security control center, or at both locations.
(2) Where the location within the protected buildings where supervisory or alarm signals are received is not under constant supervision by qualified personnel in the employ of the owner, a connection shall be provided to transmit a signal to a remote central station.
(3) A distinct trouble signal shall be provided to indicate a condition that will impair the satisfactory operation of the sprinkler system.

8.16.1.7* Alarm Service.

8.16.1.7.1 A central station, auxiliary, remote station, or proprietary sprinkler waterflow alarm shall be provided for sprinkler systems protecting storage in accordance with Section 12.2.

8.16.1.7.2 A local waterflow alarm shall be permitted where recorded guard service is provided.

8.16.1.8 Sprinkler Waterflow Alarm for In-Rack Sprinklers. See Section C.4.

8.16.2* Fire Department Connections.

8.16.2.1* Unless the requirements of 8.16.2.2 are met, a fire department connection shall be provided as described in 8.16.2 in accordance with Figure 8.16.2.1.

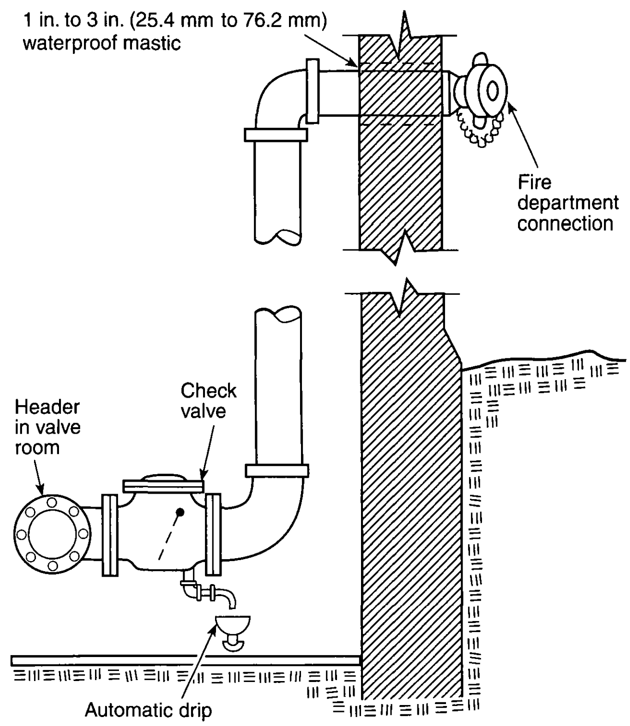


FIGURE 8.16.2.1 Fire Department Connections.

8.16.2.2 The following systems shall not require a fire department connection:

(1) Buildings located in remote areas that are inaccessible for fire department support
(2) Large-capacity deluge systems exceeding the pumping capacity of the fire department
(3) Single-story buildings not exceeding 2000 ft^2 (186 m^2) in area

8.16.2.3 Size. The size of the pipe for the fire department connection shall be in accordance with one of the following:

(1) Pipe size shall be a minimum of 4 in. (102 mm) for fire engine connections
(2) Pipe size shall be a minimum of 6 in. (152 mm) for fire boat connections
(3) For hydraulically calculated systems, the fire department connection shall be permitted to be less than 4 in. (102 mm)

and no less than the size of system riser, where serving one system riser

(4) A single-outlet fire department connection shall be acceptable where piped to a 3-in. (76-mm) or smaller riser

8.16.2.4* Arrangement. See Figure 8.16.2.1.

8.16.2.4.1* The fire department connection shall be on the system side of the water supply check valve.

8.16.2.4.2 For single systems, the fire department connection shall be installed as follows:

(1) Wet system — on the system side of system control, check, and alarm valves *(see Figure A.8.15.1.1)*
(2) Dry system — between the system control valve and the dry pipe valve
(3) Preaction system — between the preaction valve and the check valve on the system side of the preaction valve
(4) Deluge system — on the system side of the deluge valve

8.16.2.4.3 For multiple systems, the fire department connection shall be connected between the supply control valves and the system control valves.

8.16.2.4.4 The requirements of 8.16.2.4.2 and 8.16.2.4.3 shall not apply where the fire department connection is connected to the underground piping.

8.16.2.4.5 Where a fire department connection services only a portion of a building, a sign shall be attached indicating the portions of the building served.

8.16.2.4.6 Fire department connections shall be on the street side of buildings and shall be located and arranged so that hose lines can be readily and conveniently attached to the inlets without interference from any nearby objects including buildings, fences, posts, or other fire department connections.

8.16.2.4.7 Signs.

8.16.2.4.7.1 Each fire department connection to sprinkler systems shall be designated by a sign having raised or engraved letters at least 1 in. (25.4 mm) in height on plate or fitting reading service design — for example, AUTOSPKR., OPEN SPKR., AND STANDPIPE.

8.16.2.4.7.2 A sign shall also indicate the pressure required at the inlets to deliver the greatest system demand.

8.16.2.4.7.3 The sign required in 8.16.2.4.7.2 shall not be required where the system demand pressure is less than 150 psi (10.3 bar).

8.16.2.4.8 Fire department connections shall not be connected on the suction side of fire pumps.

8.16.2.4.9 Fire department connections shall be properly supported.

8.16.2.5 Valves.

8.16.2.5.1 A listed check valve shall be installed in each fire department connection.

8.16.2.5.2 There shall be no shutoff valve in the fire department connection piping.

8.16.2.6 Drainage. The piping between the check valve and the outside hose coupling shall be equipped with an approved automatic drip in areas subject to freezing.

8.16.3 Gauges.

8.16.3.1 A pressure gauge with a connection not smaller than ¼ in. (6.4 mm) shall be installed at the system main drain, at each main drain associated with a floor control valve, and on the inlet and outlet side of each pressure reducing valve.

8.16.3.2 Each gauge connection shall be equipped with a shutoff valve and provisions for draining.

8.16.3.3 The required pressure gauges shall be listed and shall have a maximum limit not less than twice the normal system working pressure at the point where installed.

8.16.3.4 Gauges shall be installed to permit removal and shall be located where they will not be subject to freezing.

8.16.4 System Connections.

8.16.4.1* Main Drain Test Connections.

8.16.4.1.1 Main drain test connections shall be provided at locations that will permit flow tests of water supplies and connections.

8.16.4.1.2 They shall be so installed that the valve can be opened wide for a sufficient time to assure a proper test without causing water damage.

8.16.4.1.3 Main drain connections shall be sized in accordance with 8.15.2.4 and 8.15.2.6.

8.16.4.2* Wet Pipe Systems.

8.16.4.2.1 An alarm test connection not less than 1 in. (25.4 mm) in diameter, terminating in a smooth bore corrosion-resistant orifice, giving a flow equivalent to one sprinkler of a type having the smallest orifice installed on the particular system, shall be provided to test each waterflow alarm device for each system.

8.16.4.2.2 The test connection valve shall be readily accessible.

8.16.4.2.3 The discharge shall be to the outside, to a drain connection capable of accepting full flow under system pressure, or to another location where water damage will not result.

8.16.4.3* Dry Pipe Systems.

8.16.4.3.1 A trip test connection not less than 1 in. (25.4 mm) in diameter, terminating in a smooth bore corrosion-resistant orifice, to provide a flow equivalent to one sprinkler of a type installed on the particular system, shall be installed.

8.16.4.3.2 The trip test connection shall be located on the end of the most distant sprinkler pipe in the upper story and shall be equipped with a readily accessible shutoff valve and plug not less than 1 in. (25.4 mm), at least one of which shall be brass.

8.16.4.3.3 In lieu of a plug, a nipple and cap shall be acceptable.

8.16.4.4 Preaction Systems.

8.16.4.4.1 A test connection shall be provided on a preaction system using supervisory air.

8.16.4.4.2 The connection used to control the level of priming water shall be considered adequate to test the operation of the alarms monitoring the supervisory air pressure.

8.16.4.5 Deluge Systems. A test connection is not required on a deluge system.

8.16.4.6* Backflow Devices.

8.16.4.6.1* Backflow Prevention Valves. Means shall be provided downstream of all backflow prevention valves for flow tests at system demand.

8.16.4.6.2 Retroactive Installation. When backflow prevention devices are to be retroactively installed on existing systems, a thorough hydraulic analysis, including revised hydraulic calculations, new fire flow data, and all necessary system modifications to accommodate the additional friction loss, shall be completed as a part of the installation.

8.16.5 Hose Connections.

8.16.5.1 Small (1½-in.) Hose Connections. See Section C.5.

8.16.5.1.1* Where required by Chapter 12, small (1½ in.) hose lines shall be available to reach all portions of the storage area.

8.16.5.1.2 The hose connections shall not be required to meet the requirements of Class II hose systems defined by NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.*

8.16.5.1.3 Hose connections shall be supplied from one of the following:

(1) Outside hydrants
(2) A separate piping system for small hose stations
(3) Valved hose connections on sprinkler risers where such connections are made upstream of all sprinkler control valves
(4) Adjacent sprinkler systems
(5) In rack storage areas, the ceiling sprinkler system in the same area (as long as in-rack sprinklers are provided in the same area and are separately controlled)

8.16.5.1.4* Hose used for fire purposes only shall be permitted to be connected to wet sprinkler systems only, subject to the following restrictions:

(1) Hose station's supply pipes connected to shall not be connected to any pipe smaller than 2½ in. (64 mm).
(2) The requirements of 8.16.5.1.4 shall not apply to hydraulically designed loops and grids, where the minimum size pipe between the hose station's supply pipe and the source shall be permitted to be 2 in. (51 mm).
(3) For piping serving a single hose station, pipe shall be a minimum of 1 in. (25.4 mm) for horizontal runs up to 20 ft (6.1 m), a minimum of 1¼ in. (33 mm) for the entire run for runs between 20 ft and 80 ft (6.1 m and 24.4 m), and a minimum of 1½ in. (38 mm) for the entire run for runs greater than 80 ft (24.4 m). For piping serving multiple hose stations, runs shall be a minimum of 1½ in. (38 mm) throughout.
(4) Piping shall be at least 1 in. (25 mm) for vertical runs.
(5) When the pressure at any hose station outlet exceeds 100 psi (6.9 bar), an approved device shall be installed at the outlet to reduce the pressure at the outlet to 100 psi (6.9 bar).

8.16.5.2* Hose Connections for Fire Department Use.

8.16.5.2.1 In buildings of light or ordinary hazard occupancy, 2½-in. (64-mm) hose valves for fire department use shall be permitted to be attached to wet pipe sprinkler system risers.

8.16.5.2.2 The following restrictions shall apply:

(1) Sprinklers shall be under separate floor control valves.
(2) The minimum size of the riser shall be 4 in. (102 mm) unless hydraulic calculations indicate that a smaller size riser will satisfy sprinkler and hose stream demands.
(3) Each combined sprinkler and standpipe riser shall be equipped with a riser control valve to permit isolating a riser without interrupting the supply to other risers from the same source of supply. *(For fire department connections serving standpipe and sprinkler systems, refer to Section 6.8.)*

Chapter 9 Hanging, Bracing, and Restraint of System Piping

9.1 Hangers.

9.1.1* General.

9.1.1.1 Unless the requirements of 9.1.1.2 are met, types of hangers shall be in accordance with the requirements of Section 9.1.

9.1.1.2 Hangers certified by a registered professional engineer to include all of the following shall be an acceptable alternative to the requirements of Section 9.1:

(1) Hangers shall be designed to support five times the weight of the water-filled pipe plus 250 lb (114 kg) at each point of piping support.
(2) These points of support shall be adequate to support the system.
(3) The spacing between hangers shall not exceed the value given for the type of pipe as indicated in Table 9.2.2.1.
(4) Hanger components shall be ferrous.
(5) Detailed calculations shall be submitted, when required by the reviewing authority, showing stresses developed in hangers, piping, and fittings and safety factors allowed.

9.1.1.3 Where water-based fire protection systems are required to be protected against damage from earthquakes, hangers shall also meet the requirements of 9.3.7.

9.1.1.4 Listing.

9.1.1.4.1 Unless permitted by 9.1.1.4.2 or 9.1.1.4.3, the components of hanger assemblies that directly attach to the pipe or to the building structure shall be listed.

9.1.1.4.2 Mild steel hangers formed from rods shall be permitted to be not listed.

9.1.1.4.3 Fasteners as specifically identified in 9.1.5 shall be permitted to be not listed.

9.1.1.4.4 Other fasteners shall be permitted as part of the hanger assembly that has been tested, listed, and installed in accordance with the listing requirements.

9.1.1.5 Component Material.

9.1.1.5.1 Unless permitted by 9.1.1.5.2 or 9.1.1.5.3, hangers and their components shall be ferrous.

9.1.1.5.2 Nonferrous components that have been proven by fire tests to be adequate for the hazard application, that are listed for this purpose, and that are in compliance with the other requirements of this section shall be acceptable.

9.1.1.5.3 Holes through solid structural members shall be permitted to serve as hangers for the support of system piping provided such holes are permitted by applicable building codes and the spacing and support provisions for hangers of this standard are satisfied.

9.1.1.6* Trapeze Hangers.

9.1.1.6.1 For trapeze hangers, the minimum size of steel angle or pipe span between purlins or joists shall be such that the available section modulus of the trapeze member from Table 9.1.1.6.1(a) equals or exceeds the section modulus required in Table 9.1.1.6.1(b).

Table 9.1.1.6.1(a) Available Section Moduli of Common Trapeze Hangers (in.^{3})

Pipe (in.)	Modulus	Angles	Modulus
Schedule 10			
1	0.12	1½ × 1½ × 3/16	0.10
1¼	0.19	2 × 2 × ⅛	0.13
1½	0.26	2 × 1½ × 3/16	0.18
2	0.42	2 × 2 × 3/16	0.19
2½	0.69	2 × 2 × ¼	0.25
3	1.04	2½ × 1½ × 3/16	0.28
3½	1.38	2½ × 2 × 3/16	0.29
4	1.76	2 × 2 × 5/16	0.30
5	3.03	2½ × 2½ × 3/16	0.30
6	4.35	2 × 2 × ⅜	0.35
		2½ × 2½ × ¼	0.39
		3 × 2 × 3/16	0.41
Schedule 40			
1	0.13	3 × 2½ × 3/16	0.43
1¼	0.23	3 × 3 × 3/16	0.44
1½	0.33	2½ × 2½ × 5/16	0.48
2	0.56	3 × 2 × ¼	0.54
2½	1.06	2½ × 2 × ⅜	0.55
3	1.72	2½ × 2½ × ⅜	0.57
3½	2.39	3 × 3 × ¼	0.58
4	3.21	3 × 3 × 5/16	0.71
5	5.45	2½ × 2½ × ½	0.72
6	8.50	3½ × 2½ × ¼	0.75
		3 × 2½ × ⅜	0.81
		3 ×3 × ⅜	0.83
		3½ × 2½ × 5/16	0.93
		3 × 3 × 7/16	0.95
		4 × 4 × ¼	1.05
		3 × 3 × ½	1.07
		4 × 3 × 5/16	1.23
		4 × 4 × 5/16	1.29
		4 × 3 × ⅜	1.46
		4 ×4 ×⅜	1.52
		5 × 3½ × 5/16	1.94
		4 × 4 × ½	1.97
		4 × 4 × ⅝	2.40
		4 × 4 × ¾	2.81
		6 × 4 × ⅜	3.32
		6 × 4 × ½	4.33
		6 × 4 × ¾	6.25
		6 × 6 × 1	8.57

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.

9.1.1.6.2 Any other sizes or shapes giving equal or greater section modulus shall be acceptable.

9.1.1.6.3 All angles shall be used with the longer leg vertical.

9.1.1.6.4 The trapeze member shall be secured to prevent slippage.

9.1.1.6.5 Where a pipe is suspended from a pipe trapeze of a diameter less than the diameter of the pipe being supported, ring, strap, or clevis hangers of the size corresponding to the suspended pipe shall be used on both ends.

9.1.1.6.6 The size of hanger rods and fasteners required to support the steel angle iron or pipe indicated in Table 9.1.1.6.1(a) shall comply with 9.1.2 through 9.1.5.

9.1.1.6.7 Holes for bolts shall not exceed 1/16 in. greater than the diameter of the bolt.

9.1.1.6.8 Bolts shall be provided with a flat washer and nut.

9.1.1.7* Support of Non-System Components. Sprinkler piping or hangers shall not be used to support non-system components.

9.1.2 Hanger Rods.

9.1.2.1 Unless the requirements of 9.1.2.2 are met, hanger rod size shall be the same as that approved for use with the hanger assembly, and the size of rods shall not be less than that given in Table 9.1.2.1.

9.1.2.2 Rods of smaller diameters than indicated in Table 9.1.2.1 shall be permitted where the hanger assembly has been tested and listed by a testing laboratory and installed within the limits of pipe sizes expressed in individual listings.

9.1.2.3 U-Hooks. The size of the rod material of U-hooks shall not be less than that given in Table 9.1.2.3.

9.1.2.4 Eye Rods.

9.1.2.4.1 The size of the rod material for eye rods shall not be less than specified in Table 9.1.2.4.1.

9.1.2.4.2 Eye rods shall be secured with lock washers to prevent lateral motion.

9.1.2.4.3 Where eye rods are fastened to wood structural members, the eye rod shall be backed with a large flat washer bearing directly against the structural member, in addition to the lock washer.

9.1.2.5 Threaded Sections of Rods. Threaded sections of rods shall not be formed or bent.

9.1.3 Fasteners in Concrete.

9.1.3.1 Unless prohibited by 9.1.3.2 or 9.1.3.3, the use of listed inserts set in concrete and listed expansion shields to support hangers shall be permitted for mains and branch lines.

9.1.3.2 Expansion shields shall not be used in cinder concrete, except for branch lines where the expansion shields are alternated with through-bolts or hangers attached to beams.

9.1.3.3 Expansion shields shall not be used in ceilings of gypsum or other similar soft material.

9.1.3.4 Unless the requirements of 9.1.3.5 are met, expansion shields shall be installed in a horizontal position in the sides of concrete beams.

Table 9.1.1.6.1(b) Section Modulus Required for Trapeze Members (in.^{3})

Span of Trapeze	Nominal Diameter of Pipe Being Supported											
	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	3½ in.	4 in.	5 in.	6 in.	8 in.	10 in.
1 ft 6 in.	0.08	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.15	0.18	0.24	0.32
	0.08	0.09	0.09	0.10	0.11	0.12	0.13	0.15	0.18	0.22	0.30	0.41
2 ft 0 in.	0.11	0.12	0.12	0.13	0.13	0.15	0.16	0.17	0.20	0.24	0.32	0.43
	0.11	0.12	0.12	0.13	0.15	0.16	0.18	0.20	0.24	0.29	0.40	0.55
2 ft 6 in.	0.14	0.14	0.15	0.16	0.17	0.18	0.20	0.21	0.25	0.30	0.40	0.54
	0.14	0.15	0.15	0.16	0.18	0.21	0.22	0.25	0.30	0.36	0.50	0.68
3 ft 0 in.	0.17	0.17	0.18	0.19	0.20	0.22	0.24	0.26	0.31	0.36	0.48	0.65
	0.17	0.18	0.18	0.20	0.22	0.25	0.27	0.30	0.36	0.43	0.60	0.82
4 ft 0 in.	0.22	0.23	0.24	0.25	0.27	0.29	0.32	0.34	0.41	0.48	0.64	0.87
	0.22	0.24	0.24	0.26	0.29	0.33	0.36	0.40	0.48	0.58	0.80	1.09
5 ft 0 in.	0.28	0.29	0.30	0.31	0.34	0.37	0.40	0.43	0.51	0.59	0.80	1.08
	0.28	0.29	0.30	0.33	0.37	0.41	0.45	0.49	0.60	0.72	1.00	1.37
6 ft 0 in.	0.33	0.35	0.36	0.38	0.41	0.44	0.48	0.51	0.61	0.71	0.97	1.30
	0.34	0.35	0.36	0.39	0.44	0.49	0.54	0.59	0.72	0.87	1.20	1.64
7 ft 0 in.	0.39	0.40	0.41	0.44	0.47	0.52	0.55	0.60	0.71	0.83	1.13	1.52
	0.39	0.41	0.43	0.46	0.51	0.58	0.63	0.69	0.84	1.01	1.41	1.92
8 ft 0 in.	0.44	0.46	0.47	0.50	0.54	0.59	0.63	0.68	0.81	0.95	1.29	1.73
	0.45	0.47	0.49	0.52	0.59	0.66	0.72	0.79	0.96	1.16	1.61	2.19
9 ft 0 in.	0.50	0.52	0.53	0.56	0.61	0.66	0.71	0.77	0.92	1.07	1.45	1.95
	0.50	0.53	0.55	0.59	0.66	0.74	0.81	0.89	1.08	1.30	1.81	2.46
10 ft 0 in.	0.56	0.58	0.59	0.63	0.68	0.74	0.79	0.85	1.02	1.19	1.61	2.17
	0.56	0.59	0.61	0.65	0.74	0.82	0.90	0.99	1.20	1.44	2.01	2.74

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Notes:
1. Top values are for Schedule 10 pipe; bottom values are for Schedule 40 pipe.
2. The table is based on a maximum allowable bending stress of 15 ksi and a midspan concentrated load from 15 ft (4.6 m) of water-filled pipe, plus 250 lb (114 kg).

Table 9.1.2.1 Hanger Rod Sizes

Pipe Size	Diameter of Rod	
	in.	mm
Up to and including 4 in.	⅜	9.5
5 in., 6 in., and 8 in.	½	12.7
10 in. and 12 in.	⅝	15.9

Table 9.1.2.3 U-Hook Rod Sizes

Pipe Size	Hook Material Diameter	
	in.	mm
Up to 2 in.	5⁄16	7.9
2½ in. to 6 in.	⅜	9.5
8 in.	½	12.7

9.1.3.5 Expansion shields shall be permitted to be installed in the vertical position under the following conditions:

(1) When used in concrete having gravel or crushed stone aggregate to support pipes 4 in. (102 mm) or less in diameter

Table 9.1.2.4.1 Eye Rod Sizes

Pipe Size	Diameter of Rod			
	With Bent Eye		With Welded Eye	
	in.	mm	in.	mm
Up to 4 in.	⅜	9.5	⅜	9.5
5 in. to 6 in.	½	12.7	½	12.7
8 in.	¾	19.1	½	12.7

(2) When expansion shields are alternated with hangers connected directly to the structural members, such as trusses and girders, or to the sides of concrete beams [to support pipe 5 in. (127 mm) or larger]
(3) When expansion shields are spaced not over 10 ft (3 m) apart [to support pipe 4 in. (102 m) or larger]

9.1.3.6 Holes for expansion shields in the side of beams shall be above the centerline of the beam or above the bottom reinforcement steel rods.

9.1.3.7 Holes for expansion shields used in the vertical position shall be drilled to provide uniform contact with the shield over its entire circumference.

9.1.3.8 The depth of the expansion shield hole shall not be less than specified for the type of shield used.

9.1.3.9 Powder-Driven Studs.

9.1.3.9.1 Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed.

9.1.3.9.2 Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

9.1.3.9.3* Representative samples of concrete into which studs are to be driven shall be tested to determine that the studs will hold a minimum load of 750 lb (341 kg) for 2-in. (51-mm) or smaller pipe, 1000 lb (454 kg) for 2½-in., 3-in., or 3½-in. (64-mm, 76-mm, or 89-mm) pipe, and 1200 lb (545 kg) for 4-in. or 5-in. (102-mm or 127-mm) pipe.

9.1.3.9.4 Increaser couplings shall be attached directly to the powder-driven studs.

9.1.3.10 Minimum Bolt Size for Concrete.

9.1.3.10.1 The size of a bolt used with a hanger and installed through concrete shall not be less than specified in Table 9.1.3.10.1.

Table 9.1.3.10.1 Minimum Bolt Size for Concrete

	Size of Bolt	
Pipe Size	**in.**	**mm**
Up to and including 4 in.	⅜	9.5
5 in. to 8 in.	½	12.7
10 in.	⅝	15.9
12 in.	¾	19.1

9.1.3.10.2 Holes for bolts shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt.

9.1.3.10.3 Bolts shall be provided with a flat washer and nut.

9.1.4 Fasteners in Steel.

9.1.4.1* Powder-driven studs, welding studs, and the tools used for installing these devices shall be listed.

9.1.4.2 Pipe size, installation position, and construction material into which they are installed shall be in accordance with individual listings.

9.1.4.3 Increaser couplings shall be attached directly to the powder-driven studs or welding studs.

9.1.4.4 Welding studs or other hanger parts shall not be attached by welding to steel less than U.S. Standard, 12 gauge.

9.1.4.5 Minimum Bolt Size for Steel.

9.1.4.5.1 The size of a bolt used with a hanger and installed through steel shall not be less than specified in Table 9.1.4.5.1.

9.1.4.5.2 Holes for bolts shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt.

9.1.4.5.3 Bolts shall be provided with a flat washer and nut.

9.1.5 Fasteners in Wood.

9.1.5.1 Drive Screws.

9.1.5.1.1 Drive screws shall be used only in a horizontal position as in the side of a beam and only for 2-in. pipe or smaller.

Table 9.1.4.5.1 Minimum Bolt Size for Steel

	Size of Bolt	
Pipe Size	**in.**	**mm**
Up to and including 4 in.	⅜	9.5
5 in. to 8 in.	½	12.7
10 in.	⅝	15.9
12 in.	¾	19.1

9.1.5.1.2 Drive screws shall only be used in conjunction with hangers that require two points of attachments.

9.1.5.2 Ceiling Flanges and U-hooks with Screws.

9.1.5.2.1 Unless the requirements of 9.1.5.2.2 or 9.1.5.2.3 are met, for ceiling flanges and U-hooks, screw dimensions shall not be less than those given in Table 9.1.5.2.1.

Table 9.1.5.2.1 Screw Dimensions for Ceiling Flanges and U-Hooks

Pipe Size	Two Screw Ceiling Flanges
Up to 2 in.	Wood screw No. 18 × 1½ in. or Lag screw 5⁄16 in. × 1½ in.
Pipe Size	**Three Screw Ceiling Flanges**
Up to 2 in.	Wood screw No.18 × 1½ in.
2½ in., 3 in., 3½ in.	Lag screw ⅜ in. × 2 in.
4 in., 5 in., 6 in.	Lag screw ½ in. × 2 in.
8 in.	Lag screw ⅝ in. × 2 in.
Pipe Size	**Four Screw Ceiling Flanges**
Up to 2 in.	Wood screw No. 18 × 1½ in.
2½ in., 3 in., 3½ in.	Lag screw ⅜ in. × 1½ in.
4 in., 5 in., 6 in.	Lag screw ½ in. × 2 in.
8 in.	Lag screw ⅝ in. × 2 in.
Pipe Size	**U-Hooks**
Up to 2 in.	Drive screw No. 16 × 2 in.
2½ in., 3 in., 3½ in.	Lag screw ⅜ in. × 2½ in.
4 in., 5 in., 6 in.	Lag screw ½ in. × 3 in.
8 in.	Lag screw ⅝ in. × 3 in.

For SI units, 1 in. = 25.4 mm.

9.1.5.2.2 When the thickness of planking and thickness of flange do not permit the use of screws 2 in. (51 mm) long, screws 1¾ in. (44 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

9.1.5.2.3 When the thickness of beams or joists does not permit the use of screws 2½ in. (64 mm) long, screws 2 in. (51 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

9.1.5.3 Bolt or Lag Screw.

9.1.5.3.1 Unless the requirements of 9.1.5.3.2 are met, the size of bolt or lag screw used with a hanger and installed on the side of the beam shall not be less than specified in Table 9.1.5.3.1.

Table 9.1.5.3.1 Minimum Bolt or Lag Screw Sizes for Side of Beam Installation

	Size of Bolt or Lag Screw		Length of Lag Screw Used with Wood Beams	
Pipe Size	in.	mm	in.	mm
Up to and including 2 in.	⅜	9.5	2½	64
2½ in. to 6 in. (inclusive)	½	12.7	3	76
8 in.	⅝	15.9	3	76

9.1.5.3.2 Where the thickness of beams or joists does not permit the use of screws 2½ in. (64 mm) long, screws 2 in. (51 mm) long shall be permitted with hangers spaced not over 10 ft (3 m) apart.

9.1.5.3.3 All holes for lag screws shall be pre-drilled ⅛ in. (3.2 mm) less in diameter than the maximum root diameter of the lag screw thread.

9.1.5.3.4 Holes for bolts shall not exceed 1⁄16 in. (1.6 mm) greater than the diameter of the bolt.

9.1.5.3.5 Bolts shall be provided with a flat washer and nut.

9.1.5.4 Wood Screws. Wood screws shall be installed with a screwdriver.

9.1.5.5 Nails. Nails shall not be acceptable for fastening hangers.

9.1.5.6 Screws in Side of Timber or Joists.

9.1.5.6.1 Screws in the side of a timber or joist shall be not less than 2½ in. (64 mm) from the lower edge where supporting branch lines and not less than 3 in. (76 mm) where supporting main lines.

9.1.5.6.2 The requirements of 9.1.5.6.1 shall not apply to 2-in. (51-mm) or thicker nailing strips resting on top of steel beams.

9.1.5.7 Coach Screw Rods.

9.1.5.7.1 Minimum Coach Screw Rod Size. The size of coach screw rods shall not be less than the requirements of Table 9.1.5.7.1.

Table 9.1.5.7.1 Minimum Coach Screw Rod Size

	Diameter of Rod		
Pipe Size	in.	mm	Minimum Penetration
Up to 4 in.	⅜	9.5	3 in.
Larger than 4 in.	Not permitted	Not permitted	Not permitted

9.1.5.7.2 The minimum plank thickness and the minimum width of the lower face of beams or joists in which coach screw rods are used shall be not less than that specified in Table 9.1.5.7.2.

Table 9.1.5.7.2 Minimum Plank Thicknesses and Beam or Joist Widths

	Nominal Plank Thickness		Nominal Width of Beam or Joist Face	
Pipe Size	in.	mm	in.	mm
Up to 2 in.	3	76	2	51
2½ in. to 3½ in.	4	102	2	51
4 in. and 5 in.	4	102	3	76
6 in.	4	102	4	102

9.1.5.7.3 Coach screw rods shall not be used for support of pipes larger than 4 in. in diameter.

9.1.5.7.4 All holes for coach screw rods shall be predrilled ⅛ in. (3.2 mm) less in diameter than the maximum root diameter of the wood screw thread.

9.2 Installation of Pipe Hangers.

9.2.1 General.

9.2.1.1 Ceiling Sheathing.

9.2.1.1.1 Unless the requirements of 9.2.1.1.2 are met, sprinkler piping shall be supported independently of the ceiling sheathing.

9.2.1.1.2 Toggle hangers shall be permitted only for the support of pipe 1½ in. (38 mm) or smaller in size under ceilings of hollow tile or metal lath and plaster.

9.2.1.2 Storage Racks. Where sprinkler piping is installed in storage racks, piping shall be supported from the storage rack structure or building in accordance with all applicable provisions of Sections 9.2 and 9.3.

9.2.1.3* Building Structure.

9.2.1.3.1 Sprinkler piping shall be substantially supported from the building structure, which must support the added load of the water-filled pipe plus a minimum of 250 lb (114 kg) applied at the point of hanging.

9.2.1.3.2 Trapeze hangers shall be used where necessary to transfer loads to appropriate structural members.

9.2.1.4 Metal Deck.

9.2.1.4.1 Branch line hangers under metal deck shall be permitted only for the support of pipe 1 in. (25.4 mm) or smaller in size, by drilling or punching vertical members and using through bolts.

9.2.1.4.2 The distance from the bottom of the bolt hole to the bottom of the vertical member shall be not less than ⅜ in. (9.5 mm).

9.2.1.5 Where sprinkler piping is installed below ductwork, piping shall be supported from the building structure or from the ductwork supports, provided such supports are capable of handling both the load of the ductwork and the load specified in 9.2.1.3.1.

9.2.2* Maximum Distance between Hangers.

9.2.2.1 The maximum distance between hangers shall not exceed that specified in Table 9.2.2.1.

9.2.2.2 The maximum distance between hangers for listed nonmetallic pipe shall be modified as specified in the individual product listings.

9.2.3 Location of Hangers on Branch Lines.

9.2.3.1 Subsection 9.2.3 shall apply to the support of steel pipe or copper tube as specified in 6.3.1 and subject to the provisions of 9.2.2.

9.2.3.2 Minimum Number of Hangers.

9.2.3.2.1 Unless the requirements of 9.2.3.2.2 or 9.2.3.2.3 are met, there shall be not less than one hanger for each section of pipe.

9.2.3.2.2* Where sprinklers are spaced less than 6 ft (1.8 m) apart, hangers spaced up to a maximum of 12 ft (3.7 m) shall be permitted.

9.2.3.2.3 Starter lengths less than 6 ft (1.8 m) shall not require a hanger, unless on the end line of a sidefeed system or where an intermediate cross main hanger has been omitted.

9.2.3.3 Clearance to Hangers. The distance between a hanger and the centerline of an upright sprinkler shall not be less than 3 in. (76 mm).

9.2.3.4* Unsupported Lengths.

9.2.3.4.1 The unsupported length between the end sprinkler and the last hanger on the line shall not be greater than 36 in. (0.9 m) for 1-in. pipe, 48 in. (1.2 m) for 1¼-in. pipe, and 60 in. (1.5 m) for 1½-in. or larger pipe.

9.2.3.4.2 Where the limits of 9.2.3.4.1 are exceeded, the pipe shall be extended beyond the end sprinkler and shall be supported by an additional hanger.

9.2.3.4.3* Unsupported Length with Maximum Pressure Exceeding 100 psi.

9.2.3.4.3.1 When the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds 100 psi (6.9 bar) and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the hanger assembly supporting the pipe supplying an end sprinkler in a pendent position shall be of a type that prevents upward movement of the pipe.

9.2.3.4.3.2 The unsupported length between the end sprinkler in a pendent position or drop nipple and the last hanger on the branch line shall not be greater than 12 in. (305 mm) for steel pipe or 6 in. (152 mm) for copper pipe.

9.2.3.4.3.3 When the limit of 9.2.3.4.3.2 is exceeded, the pipe shall be extended beyond the end sprinkler and supported by an additional hanger.

9.2.3.4.3.4 The hanger closest to the sprinkler shall be of a type that prevents upward movement of the piping.

9.2.3.5* Unsupported Armover Length.

9.2.3.5.1 The cumulative horizontal length of an unsupported armover to a sprinkler, sprinkler drop, or sprig-up shall not exceed 24 in. (610 mm) for steel pipe or 12 in. (305 mm) for copper tube.

9.2.3.5.2* Unsupported Armover Length with Maximum Pressures Exceeding 100 psi.

9.2.3.5.2.1 Where the maximum static or flowing pressure, whichever is greater at the sprinkler, applied other than through the fire department connection, exceeds 100 psi (6.9 bar) and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the cumulative horizontal length of an unsupported armover to a sprinkler or sprinkler drop shall not exceed 12 in. (305 mm) for steel pipe and 6 in. (152 mm) for copper tube.

9.2.3.5.2.2 The hanger closest to the sprinkler shall be of a type that prevents upward movement of the piping.

9.2.3.6 Wall-mounted sidewall sprinklers shall be restrained to prevent movement.

9.2.4 Location of Hangers on Mains.

9.2.4.1 Unless the requirements of 9.2.4.2, 9.2.4.3, 9.2.4.4, or 9.2.4.5 are met, hangers for mains shall be in accordance with 9.2.2 or between each branch line, whichever is the lesser dimension.

9.2.4.2 For cross mains in steel pipe systems in bays having two branch lines, the intermediate hanger shall be permitted to be omitted provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main

Table 9.2.2.1 Maximum Distance Between Hangers (ft-in.)

	Nominal Pipe Size (in.)											
	¾	1	1¼	1½	2	2½	3	3½	4	5	6	8
Steel pipe except threaded lightwall	N/A	12-0	12-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0	15-0
Threaded lightwall steel pipe	N/A	12-0	12-0	12-0	12-0	12-0	12-0	N/A	N/A	N/A	N/A	N/A
Copper tube	8-0	8-0	10-0	10-0	12-0	12-0	12-0	15-0	15-0	15-0	15-0	15-0
CPVC	5-6	6-0	6-6	7-0	8-0	9-0	10-0	N/A	N/A	N/A	N/A	N/A
Polybutylene (IPS)	N/A	3-9	4-7	5-0	5-11	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Polybutylene (CTS)	2-11	3-4	3-11	4-5	5-5	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ductile iron pipe	N/A	N/A	N/A	N/A	N/A	N/A	15-0	N/A	15-0	N/A	15-0	15-0

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: IPS iron — *pipe size;* CTS — copper tube size.

as the location of the purlin permits. The remaining branch line hangers shall be installed in accordance with 9.2.3.

9.2.4.3 For cross mains in steel pipe systems only in bays having three branch lines, either side or center feed, one (only) intermediate hanger shall be permitted to be omitted provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits. The remaining branch line hangers shall be installed in accordance with 9.2.3.

9.2.4.4 For cross mains in steel pipe systems only in bays having four or more branch lines, either side or center feed, two intermediate hangers shall be permitted to be omitted provided the maximum distance between hangers does not exceed the distances specified in 9.2.2 and a hanger attached to a purlin on each branch line is located as near to the cross main as the purlin permits.

9.2.4.5 At the end of the main, intermediate trapeze hangers shall be installed unless the main is extended to the next framing member with a hanger installed at this point, in which event an intermediate hanger shall be permitted to be omitted in accordance with 9.2.4.2, 9.2.4.3, and 9.2.4.4.

9.2.5 Support of Risers.

9.2.5.1 Risers shall be supported by pipe clamps or by hangers located on the horizontal connections within 24 in. of the centerline of the riser.

9.2.5.2 Pipe clamps supporting risers by means of set screws shall not be used.

9.2.5.3 Multistory Buildings.

9.2.5.3.1 In multistory buildings, riser supports shall be provided at the lowest level, at each alternate level above, above and below offsets, and at the top of the riser.

9.2.5.3.2 Supports above the lowest level shall also restrain the pipe to prevent movement by an upward thrust where flexible fittings are used.

9.2.5.3.3 Where risers are supported from the ground, the ground support shall constitute the first level of riser support.

9.2.5.3.4 Where risers are offset or do not rise from the ground, the first ceiling level above the offset shall constitute the first level of riser support.

9.2.5.4 Distance between supports for risers shall not exceed 25 ft (7.6 m).

9.3 Protection of Piping Against Damage Where Subject to Earthquakes.

9.3.1* General.

9.3.1.1 Where water-based fire protection systems are required to be protected against damage from earthquakes, the requirements of Section 9.3 shall apply, unless the requirements of 9.3.1.2 are met.

9.3.1.2 Alternative methods of providing earthquake protection of sprinkler systems based on a seismic analysis certified by a registered professional engineer such that system performance will be at least equal to that of the building structure under expected seismic forces shall be permitted.

9.3.2* Couplings.

9.3.2.1 Listed flexible pipe couplings joining grooved end pipe shall be provided as flexure joints to allow individual sections of piping 2½ in. (64 mm) or larger to move differentially with the individual sections of the building to which it is attached.

9.3.2.2 Couplings shall be arranged to coincide with structural separations within a building.

9.3.2.3 Systems having more flexible couplings than required by this section shall be provided with additional sway bracing as required in 9.3.5.3.6. The flexible couplings shall be installed as follows:

(1) Within 24 in. (610 mm) of the top and bottom of all risers, unless the following provisions are met:
   (a) In risers less than 3 ft (0.9 m) in length, flexible couplings are permitted to be omitted.
   (b) In risers 3 ft to 7 ft (0.9 m to 2.1 m) in length, one flexible coupling is adequate.
(2)*Within 12 in. (305 mm) above and within 24 in. below the floor in multistory buildings. When the flexible coupling below the floor is above the tie-in main to the main supplying that floor, a flexible coupling shall be provided on the vertical portion of the tie-in piping.
(3) On both sides of concrete or masonry walls within 1 ft of the wall surface, unless clearance is provided in accordance with 9.3.4.
(4)*Within 24 in. (610 mm) of building expansion joints.
(5) Within 24 in. (610 mm) of the top and bottom of drops to hose lines, rack sprinklers, and mezzanines, regardless of pipe size.
(6) Within 24 in. (610 mm) of the top of drops exceeding 15 ft (4.6 m) in length to portions of systems supplying more than one sprinkler, regardless of pipe size.
(7) Above and below any intermediate points of support for a riser or other vertical pipe.

9.3.3* Seismic Separation Assembly. Seismic separation assemblies with flexible fittings shall be installed where sprinkler piping, regardless of size, crosses building seismic separation joints above ground level.

9.3.4* Clearance.

9.3.4.1 Clearance shall be provided around all piping extending through walls, floors, platforms, and foundations, including drains, fire department connections, and other auxiliary piping.

9.3.4.2 Unless the requirements of 9.3.4.3, 9.3.4.4, or 9.3.4.5 are met, where pipe passes through holes in platforms, foundations, walls, or floors, the holes shall be sized such that the diameter of the holes is nominally 2 in. (51 mm) larger than the pipe for 1-in. (25.4-mm) nominal to 3½-in. (89-mm) nominal and 4-in. (102-mm) larger than the pipe for pipe 4 in. (102 mm) nominal and larger. Clearance from structural members not penetrated or used collectively or independently to support the pipe shall be at least 2 in. (51 mm).

9.3.4.3 Where clearance is provided by a pipe sleeve, a nominal diameter 2 in. (51 mm) larger than the nominal diameter of the pipe is acceptable for pipe sizes 1 in. (25.4 mm) through 3½ in. (89 mm), and the clearance provided by a pipe sleeve of nominal diameter 4 in. (102 mm) larger than the nominal diameter of the pipe is acceptable for pipe sizes 4 in. (102 mm) and larger.

9.3.4.4 No clearance is required for piping passing through gypsum board or equally frangible construction that is not required to have a fire resistance rating.

9.3.4.5 No clearance is required if flexible couplings are located within 1 ft (0.31 m) of each side of a wall, floor, platform, or foundation.

9.3.4.6 No clearance is required where horizontal piping passes perpendicularly through successive studs or joists that form a wall or floor/ceiling assembly.

9.3.4.7 No clearance is required where nonmetallic pipe has been demonstrated to have inherent flexibility equal to or greater than the minimum provided by flexible couplings located within 1 ft (0.3 m) of each side of a wall, floor, platform, or foundation.

9.3.4.8 Where required, the clearance shall be filled with a flexible material such as mastic.

9.3.4.9 Clearance from structural members not penetrated or used, collectively or independently, to support the piping shall be at least 2 in. (51 mm).

9.3.5* Sway Bracing.

9.3.5.1 General.

9.3.5.1.1 The system piping shall be braced to resist both lateral and longitudinal horizontal seismic loads and to prevent vertical motion resulting from seismic loads.

9.3.5.1.2 The structural components to which bracing is attached shall be determined to be capable of carrying the added applied seismic loads.

9.3.5.2 Sway Bracing.

9.3.5.2.1 Sway braces shall be designed to withstand forces in tension and compression, unless the requirements of 9.3.5.2.2 are met.

9.3.5.2.2* Tension-only bracing systems shall be permitted for use where listed for this service and where installed in accordance with their listing limitations, including installation instructions.

9.3.5.3 Lateral Sway Bracing.

9.3.5.3.1 Lateral sway bracing spaced at a maximum interval of 40 ft (12.2 m) on center shall be provided on all feed and cross mains regardless of size and all branch lines and other piping with a diameter of 2½ in. (63.5 mm) and larger.

9.3.5.3.2 The distance between the last brace and the end of the pipe shall not exceed 20 ft (6.1 m).

9.3.5.3.3 The requirements of 9.3.5.3.1 and 9.3.5.3.2 shall not apply where building primary structural members exceed 40 ft (12.2 m) on center, lateral braces shall be permitted to be spaced up to 50 ft (15.2 m) on center, and the distance between the last brace and the end of the pipe shall be permitted to be extended to 25 ft (7.6 m).

9.3.5.3.4 The last length of pipe at the end of a feed or cross main shall be provided with a lateral brace.

9.3.5.3.5 Lateral braces shall be allowed to act as longitudinal braces if they are within 24 in. (610 mm) of the centerline of the piping braced longitudinally for lines that are 2½ in. (63.5 mm) and greater in diameter.

9.3.5.3.6 Where flexible couplings are installed on mains other than as required in 9.3.2, a lateral brace shall be provided within 24 in. (610 mm) of every other coupling, but not more than 40 ft (12.2 m) on center.

9.3.5.3.7 The requirements of 9.3.5.3 shall not apply to pipes individually supported by rods less than 6 in. (152 mm) long measured between the top of the pipe and the point of attachment to the building structure.

9.3.5.3.8 The requirements of 9.3.5.3 shall not apply where U-type hooks of the wraparound type or those U-type hooks arranged to keep the pipe tight to the underside of the structural element shall be permitted to be used to satisfy the requirements for lateral sway bracing, provided the legs are bent out at least 30 degrees from the vertical and the maximum length of each leg and the rod size satisfies the conditions of Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c).

9.3.5.4 Longitudinal Sway Bracing.

9.3.5.4.1 Longitudinal sway bracing spaced at a maximum of 80 ft (24.4 m) on center shall be provided for feed and cross mains.

9.3.5.4.2 Longitudinal braces shall be permitted to serve as lateral braces where they are installed within 24 in. (610 mm) of the piping that is braced laterally.

9.3.5.4.3 The distance between the last brace and the end of the pipe shall not exceed 40 ft (12.2 m).

9.3.5.5 Risers.

9.3.5.5.1* Tops of risers exceeding 3 ft (1 m) in length shall be provided with a four-way brace.

9.3.5.5.2 Distance between four-way braces for risers shall not exceed 25 ft (7.6 m).

9.3.5.5.3 Four-way bracing shall not be required where risers penetrate intermediate floors in multistory buildings where the clearance does not exceed the limits of 9.3.4.

9.3.5.6* Horizontal Force Factors.

9.3.5.6.1 Unless the requirements of 9.3.5.6.2 are met, the horizontal loads for braces shall be determined by analysis based on a horizontal force of $F_p = 0.5\ W_p$, where F_p is the horizontal force factor and W_p is 1.15 times the weight of the water-filled piping.

9.3.5.6.2 Where the use of horizontal force factors other than the horizontal force factor required by 9.3.5.6.1 is required or permitted by the authority having jurisdiction, they shall take precedence.

9.3.5.6.3 For lateral braces, the load shall include all branch lines and mains, unless the branch lines are provided with longitudinal bracing, within the zone of influence of the brace.

9.3.5.6.4 For longitudinal braces, the load shall include all mains within the zone of influence of the brace.

9.3.5.7 Horizontal Force Factors. Where the horizontal force factors used exceed 0.5 W_p and the brace angle is less than 45 degrees from vertical or where the horizontal force factor exceeds 1.0 W_p and the brace angle is less than 60 degrees from vertical, the braces shall be arranged to resist the net vertical reaction produced by the horizontal load.

9.3.5.8* Horizontal Loads.

9.3.5.8.1 Sway bracing shall be tight.

9.3.5.8.2 For individual braces, the slenderness ratio (l/r) shall not exceed 300 where l is the length of the brace and r is the least radius of gyration.

9.3.5.8.3 Where threaded pipe is used as part of a sway brace assembly, it shall not be less than Schedule 30.

9.3.5.8.4 All parts and fittings of a brace shall lie in a straight line to avoid eccentric loadings on fittings and fasteners.

9.3.5.8.5 For longitudinal braces only, the brace shall be permitted to be connected to a tab welded to the pipe in conformance with 6.5.2.

9.3.5.8.6 For individual braces, the slenderness ratio, l/r, shall not exceed 300 where l is the length of the brace and r is the least radius of gyration.

9.3.5.8.7 For tension-only braces, two tension-only brace components opposing each other must be installed at each lateral or longitudinal brace location.

9.3.5.8.8 For all braces, whether or not listed, the maximum allowable horizontal load shall be based on the weakest component of the brace with safety factors.

9.3.5.8.9 The loads determined in 9.3.5.6 shall not exceed the lesser of the maximum allowable loads provided in Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c) or the manufacturer's certified maximum allowable horizontal loads for 30- to 44-degree, 45- to 59-degree, 60- to 89-degree, and 90-degree brace angles.

9.3.5.8.10 These certified allowable horizontal loads must include a minimum safety factor of 1.5 against the ultimate break strength of the brace components and then be further reduced according to the brace angles.

9.3.5.8.11 Other pipe schedules and materials not specifically included in Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c) shall be permitted to be used if certified by a registered professional engineer to support the loads determined in accordance with the above criteria. Calculations shall be submitted where required by the authority having jurisdiction.

9.3.5.9* Fasteners.

9.3.5.9.1 For individual fasteners, the loads determined in 9.3.5.6 shall not exceed the allowable loads provided in Figure 9.3.5.9.1.

9.3.5.9.2 The type of fasteners used to secure the bracing assembly to the structure shall be limited to those shown in Figure 9.3.5.9.1.

9.3.5.9.3 For connections to wood, through-bolts with washers on each end shall be used, unless the requirements of 9.3.5.9.4 are met.

9.3.5.9.4 Where it is not practical to install through bolts due to the thickness of the member or inaccessibility, lag screws shall be permitted. Holes shall be pre-drilled ⅛ in. (3.2 mm) smaller than the maximum root diameter of the lag screw.

9.3.5.9.5 Holes for through bolts shall be 1/16 in. (1.6 mm) greater than the diameter of the bolt.

9.3.5.9.6 The requirements of 9.3.5.9 shall not apply to other fastening methods, which shall be acceptable for use if certified by a registered professional engineer to support the loads determined in accordance with the criteria in 9.3.5.9. Calculations shall be submitted where required by the authority having jurisdiction.

9.3.5.10 Assemblies.

9.3.5.10.1 Sway bracing assemblies shall be listed for a maximum load rating, unless the requirements of 9.3.5.10.2 are met.

9.3.5.10.2 Where sway bracing utilizing pipe, angles, flats, or rods as shown in Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c) is used, the components do not require listing. Bracing fittings and connections used with those specific materials shall be listed.

Table 9.3.5.8.9(a) Maximum Horizontal Loads for Sway Braces with l/r=100

Shape and Size	Least Radius of Gyration	Maximum Length for:	Maximum Horizontal Load (lb) 30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe (Schedule 40)	$\frac{\sqrt{r_0^2 + r_i^2}}{2}$	l/r=100			
1 in.	0.42	3 ft 6 in.	7,068	9,996	12,242
1¼ in.	0.54	4 ft 6 in.	9,567	13,530	16,570
1½ in.	0.623	5 ft 2 in.	11,441	16,181	19,817
2 in.	0.787	6 ft 6 in.	15,377	21,746	26,634
Rods	$=\frac{r}{2}$	l/r=100			
⅜ in.	0.094	0 ft 9 in.	1,580	2,234	2,737
½ in.	0.125	1 ft 0 in.	2,809	3,972	4,865
⅝ in.	0.156	1 ft 3 in.	4,390	6,209	7,605
¾ in.	0.188	1 ft 6 in.	6,322	8,941	10,951
⅞ in.	0.219	1 ft 9 in.	8,675	12,169	14,904

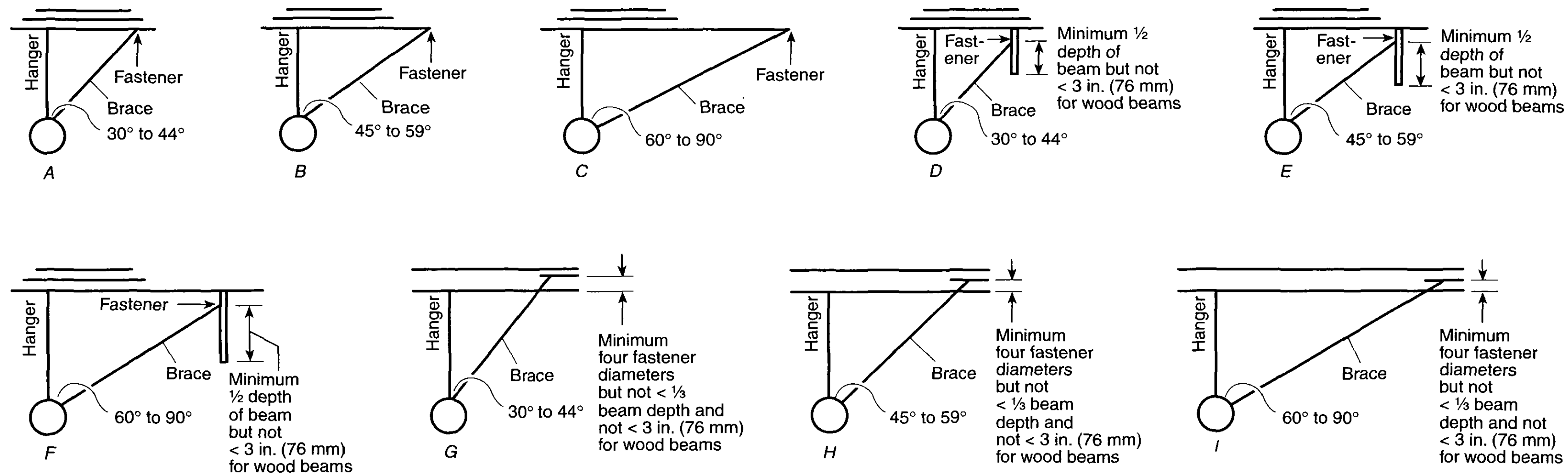
Table 9.3.5.8.9(b) Maximum Horizontal Loads for Sway Braces with l/r=200

Shape and Size	Least Radius of Gyration	Maximum Length for:	Maximum Horizontal Load (lb) 30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe (Schedule 40)	$\frac{\sqrt{r_0^2 + r_i^2}}{2}$	l/r=200			
1 in.	0.42	7 ft 0 in.	1,767	2,500	3,061
1¼ in.	0.54	9 ft 0 in.	2,392	3,385	4,145
1½ in.	0.623	10 ft 4 in.	2,858	4,043	4,955
2 in.	0.787	13 ft 1 in.	3,828	5,414	6,630
Angles		l/r = 200			
1½ × 1½ × ¾ in.	0.292	4 ft 10 in.	2,461	3,481	4,263
2 × 2 × ¼ in.	0.391	6 ft 6 in.	3,356	4,746	5,813
2½ × 2 × ¼ in.	0.424	7 ft 0 in.	3,792	5,363	6,569
2½ × 2½ × ¼ in.	0.491	8 ft 2 in.	4,257	6,021	7,374
3 × 2½ × ¼ in.	0.528	8 ft 10 in.	4,687	6,628	8,118
3 × 3 × ¼ in.	0.592	9 ft 10 in.	5,152	7,286	8,923
Rods	$= \frac{r}{2}$	l/r = 200			
⅜ in.	0.094	1 ft 6 in.	395	559	685
½ in.	0.125	2 ft 6 in.	702	993	1,217
⅝ in.	0.156	2 ft 7 in.	1,087	1,537	1,883
¾ in.	0.188	3 ft 1 in.	1,580	2,235	2,737
⅞ in.	0.219	3 ft 7 in.	2,151	3,043	3,726
Flats	= 0.29h (where h is smaller of two side dimensions)	l/r = 200			
1½ × ¼ in.	0.0725	1 ft 2 in.	1,118	1,581	1,936
2 × ¼ in.	0.0725	1 ft 2 in.	1,789	2,530	3,098
2 × ⅜ in.	0.109	1 ft 9 in.	2,683	3,795	4,648

Table 9.3.5.8.9(c) Maximum Horizontal Loads for Sway Braces with l/r=300

Shape and Size	Least Radius of Gyration	Maximum Length for:	Maximum Horizontal Load (lb) 30° to 44° Angle from Vertical	45° to 59° Angle from Vertical	60° to 90° Angle from Vertical
Pipe (Schedule 40)	$\frac{\sqrt{r_0^2 + r_i^2}}{2}$	l/r = 300			
1 in.	0.42	10 ft 6 in.	786	1,111	1,360
1¼ in.	0.54	13 ft 6 in.	1,063	1,503	1,841
1½ in.	0.623	15 ft 7 in.	1,272	1,798	2,202
2 in.	0.787	19 ft 8 in.	1,666	2,355	2,885
Rods	$= \frac{r}{2}$	l/r = 300			
⅜ in.	0.094	2 ft 4 in.	176	248	304
½ in.	0.125	3 ft 1 in.	312	441	540
⅝ in.	0.156	3 ft 11 in.	488	690	845
¾ in.	0.219	5 ft 6 in.	956	1,352	1,656

Note: Loads (given in pounds) are keyed to vertical angles of braces and orientation of connecting surface. These values are based on concentric loadings of the fastener. Use figures to determine proper reference within table. For angles between those shown, use most restrictive case. Braces should not be attached to light structure members.



Note: For wooden beams not less than 3 in. (76 mm).

Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain — Holes Predrilled Using Good Practice)

Shank Diameter of Lag (in.)

3/8

Length under head (in.)	A	B	C	D	E	F	G	H	I
3	304	325	292	168	325	526	230	324	400
4	392	354	317	183	354	678	250	352	435
5	476	375	336	194	375	824	265	373	461
6	564	382	342	196	382	976	270	380	470
8	—	—	—	—	—	—	—	—	—

1/2

Length under head (in.)	A	B	C	D	E	F	G	H	I
3	366	—	—	—	—	632	—	—	—
4	473	509	456	264	509	818	360	507	626
5	582	545	488	282	545	1008	385	542	670
6	689	559	501	288	559	1192	395	556	687
8	905	573	513	296	573	1586	405	570	704

5/8

Length under head (in.)	A	B	C	D	E	F	G	H	I
3	410	—	—	—	—	716	—	—	—
4	538	—	—	—	—	929	—	—	—
5	687	728	653	277	728	1154	515	725	896
6	791	778	697	403	778	1360	550	775	957
8	1044	806	723	416	806	1807	570	803	991

7/8

Length under head (in.)	A	B	C	D	E	F	G	H	I
3	487	—	—	—	—	843	—	—	—
4	548	—	—	—	—	1122	—	—	—
5	813	—	—	—	—	1407	—	—	—
6	971	—	—	—	—	1630	—	—	—
8	1297	1365	1223	685	1365	2244	965	1359	1678

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 lb = 0.45 kg.

FIGURE 9.3.5.9.1 Maximum Loads for Various Types of Structure and Maximum Loads for Various Types of Fasteners to Structure.

FIGURE 9.3.5.9.1 *Continued*

Through Bolts in Wood (Load Perpendicular to Grain)

Diameter of Bolt (in.)

Length of Bolt in Timber (in.)	⅜ ABCE	⅜ D	⅜ F	⅜ G	⅜ H	⅜ I	½ ABCE	½ D	½ F	½ G	½ H	½ I
1½	300	173	519	150	211	261	340	197	589	170	239	296
2	370	214	641	185	261	322	420	243	727	210	296	365
2½	460	266	796	230	324	400	550	318	952	275	387	478
3	480	277	831	240	338	417	630	364	1091	315	444	548
3⅝	460	268	797	230	324	400	720	416	1247	360	507	626
5½	—	—	—	—	—	—	680	393	1177	340	479	591

Length of Bolt in Timber (in.)	⅝ ABCE	⅝ D	⅝ F	⅝ G	⅝ H	⅝ I	⅞ ABCE	⅞ D	⅞ F	⅞ G	⅞ H	⅞ I
1½	390	225	675	195	275	339	470	272	614	235	331	409
2	470	272	814	235	331	409	580	335	1004	290	408	504
2½	620	358	1074	310	437	539	760	439	1316	380	535	661
3	710	410	1229	355	500	617	870	503	1506	435	613	757
3⅝	850	491	1472	425	599	739	1050	607	1818	525	739	913
5½	1020	590	1766	510	718	887	1580	913	2736	790	1113	1374

For SI units, 1 in. = 25.4 mm; 1 lb = 0.45 kg.

Expansion Shields in Concrete

Diameter of Bolt (in.)

Min. Depth of Hole (in.)	⅜ A	⅜ B	⅜ C	⅜ D	⅜ E	⅜ F	⅜ G	⅜ H	⅜ I	½ A	½ B	½ C	½ D	½ E	½ F	½ G	½ H	½ I
2½	498	962	1173	678	668	860	925	1303	1609	—	—	—	—	—	—	1638	2306	2848
3¼	—	—	—	—	—	—	925	1303	1609	923	1782	2076	1200	1782	1597	1638	2306	2848
3¾	—	—	—	—	—	—	925	1303	1609	—	—	—	—	—	—	1638	2306	2848
4½	—	—	—	—	—	—	925	1303	1609	—	—	—	—	—	—	1638	2306	2848

Min. Depth of Hole (in.)	⅝ A	⅝ B	⅝ C	⅝ D	⅝ E	⅝ F	⅝ G	⅝ H	⅝ I	⅞ A	⅞ B	⅞ C	⅞ D	⅞ E	⅞ F	⅞ G	⅞ H	⅞ I
2½	—	—	—	—	—	—	2080	2930	3617	—	—	—	—	—	—	2470	4113	5078
3¼	—	—	—	—	—	—	2080	2930	3617	—	—	—	—	—	—	2970	4113	5078
3¾	1480	2857	2637	1524	2857	2581	2080	2930	3617	—	—	—	—	—	—	2970	4113	5078
4½	—	—	—	—	—	—	2080	2930	3617	3070	4130	3702	2139	4130	5312	2970	4113	5078

For SI units, 1 in. = 25.4 mm; 1 lb = 0.45 kg.

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface)

Diameter of Unfinished Steel Bolt (in.)

¼ A	¼ B	¼ C	¼ D	¼ E	¼ F	¼ G	¼ H	¼ I	⅜ A	⅜ B	⅜ C	⅜ D	⅜ E	⅜ F	⅜ G	⅜ H	⅜ I
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278

½ A	½ B	½ C	½ D	½ E	½ F	½ G	½ H	½ I	⅝ A	⅝ B	⅝ C	⅝ D	⅝ E	⅝ F	⅝ G	⅝ H	⅝ I
1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 lb = 0.45 kg.

Table 9.3.5.10.3 Allowable Horizontal Load on Brace Assemblies Based on the Weakest Component of the Brace Assembly

Brace Angle	Allowable Horizontal Load
30–44 degrees from vertical	Listed load rating divided by 2.000
45–59 degrees from vertical	Listed load rating divided by 1.414
60–89 degrees from vertical	Listed load rating divided by 1.155
90 degrees from vertical	Listed load rating

9.3.5.10.3 The loads shall be reduced as shown in Table 9.3.5.10.3 for loads that are less than 90 degrees from vertical.

9.3.5.11 Attachments.

9.3.5.11.1 Bracing shall be attached directly to feed and cross mains.

9.3.5.11.2 Each run of pipe between changes in direction shall be provided with both lateral and longitudinal bracing, unless the requirements of 9.3.5.11.3 are met.

9.3.5.11.3 Pipe runs less than 12 ft (3.6 m) in length shall be permitted to be supported by the braces on adjacent runs of pipe.

9.3.5.12 Braces to Buildings with Differential Movement. A length of pipe shall not be braced to sections of the building that will move differentially.

9.3.6 Restraint of Branch Lines.

9.3.6.1* Restraint is considered a lesser degree of resisting loads than bracing and shall be provided by use of one of the following:

(1) A listed sway brace assembly
(2) A wraparound U-hook satisfying the requirements of 9.3.5.3.8
(3) No. 12, 440-lb (200-kg) wire installed at least 45 degrees from the vertical plane and anchored on both sides of the pipe
(4) Other approved means

9.3.6.2 Wire used for restraint shall be located within 2 ft (610 mm) of a hanger. The hanger closest to a wire restraint shall be of a type that resists upward movement of a branch line.

9.3.6.3 The end sprinkler on a line shall be restrained against excessive vertical and lateral movement.

9.3.6.4* Where upward or lateral movement of the system piping would result in damage to the sprinkler through impact against the building structure, equipment, or finish materials, branch lines shall be restrained at intervals not exceeding 30 ft (9 m).

9.3.6.5* Sprig-ups 4 ft (1.2 m) or longer shall be restrained against lateral movement.

9.3.7 Hangers and Fasteners Subject to Earthquakes.

9.3.7.1 C-type clamps (including beam and large flange clamps) used to attach hangers to the building structure in areas subject to earthquakes shall be equipped with a restraining strap.

9.3.7.2 The restraining strap shall be listed for use with a C-type clamp or shall be a steel strap of not less than 16 gauge thickness and not less than 1 in. (25.4 mm) wide for pipe diameters 8 in. (203 mm) or less and 14 gauge thickness and not less than 1¼ in. (31.7 mm) wide for pipe diameters greater than 8 in. (203 mm).

9.3.7.3 The restraining strap shall wrap around the beam flange not less than 1 in. (25.4 mm).

9.3.7.4 A lock nut on a C-type clamp shall not be used as a method of restraint.

9.3.7.5 A lip on a "C" or "Z" purlin shall not be used as a method of restraint.

9.3.7.6 Where purlins or beams do not provide an adequate lip to be secured by a restraining strap, the strap shall be through-bolted or secured by a self-tapping screw.

9.3.7.7 C-type clamps (including beam and large flange clamps), with or without restraining straps, shall not be used to attach braces to the building structure.

9.3.7.8 Powder-driven fasteners shall not be used to attach braces to the building structure, unless they are specifically listed for service in resisting lateral loads in areas subject to earthquakes.

9.3.7.9 In areas where the horizontal force factor exceeds 0.50 W_p, powder-driven studs shall be permitted to attach hangers to the building structure where they are specifically listed for use in areas subject to earthquakes.

Chapter 10 Underground Piping

10.1* Piping Materials.

10.1.1* Listing. Piping shall be listed for fire protection service and shall comply with the standards in Table 10.1.1.

10.1.2 Steel Pipe. Steel piping shall not be used for general underground service unless specifically listed for such service.

10.1.3 Steel Pipe Used with Fire Department Connections. Where externally coated and wrapped and internally galvanized, steel pipe shall be permitted to be used between the check valve and the outside hose coupling for the fire department connection.

10.1.4* Pipe Type and Class. The type and class of pipe for a particular underground installation shall be determined through consideration of the following factors:

(1) Fire resistance of the pipe
(2) Maximum system working pressure
(3) Depth at which the pipe is to be installed
(4) Soil conditions
(5) Corrosion
(6) Susceptibility of pipe to other external loads, including earth loads, installation beneath buildings, and traffic or vehicle loads

10.1.5 Working Pressure. Pipe shall be designed to withstand a system working pressure of not less than 150 psi (10.3 bar).

10.1.6* Lining of Buried Pipe.

10.1.6.1 Unless the requirements of 10.1.6.2 are met, all ferrous metal pipe shall be lined in accordance with the applicable standards in Table 10.1.1.

Table 10.1.1 Manufacturing Standards for Underground Pipe

Materials and Dimensions	Standard
Ductile Iron	
Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water	AWWA C104
Polyethylene Encasement for Ductile Iron Pipe Systems	AWWA C105
Ductile Iron and Gray Iron Fittings, 3-in. Through 48-in., for Water and Other Liquids	AWWA C110
Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings	AWWA C111
Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges	AWWA C115
Thickness Design of Ductile Iron Pipe	AWWA C150
Ductile Iron Pipe, Centrifugally Cast for Water	AWWA C151
Standard for the Installation of Ductile Iron Water Mains and Their Appurtenances	AWWA C600
Steel	
Steel Water Pipe 6 in. and Larger	AWWA C200
Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape — Hot Applied	AWWA C203
Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 in. and Larger — Shop Applied	AWWA C205
Field Welding of Steel Water Pipe	AWWA C206
Steel Pipe Flanges for Waterworks Service — Sizes 4 in. Through 144 in.	AWWA C207
Dimensions for Fabricated Steel Water Pipe Fittings	AWWA C208
A Guide for Steel Pipe Design and Installation	AWWA M11
Concrete	
Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids	AWWA C300
Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids	AWWA C301
Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids	AWWA C302
Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids	AWWA C303
Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water and Other Liquids	AWWA C400
Standard Practice for Selection of Asbestos-Cement Water Pipe	AWWA C401
Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place	AWWA C602
Standard for the Installation of Asbestos-Cement Water Pipe	AWWA C603
Plastic	
Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water and Other Liquids	AWWA C900
Copper	
Specification for Seamless Copper Tube	ASTM B 75
Specification for Seamless Copper Water Tube	ASTM B 88
Requirements for Wrought Seamless Copper and Copper-Alloy Tube	ASTM B 251

10.1.6.2 Steel pipe utilized in fire department connections and protected in accordance with the requirements of 10.1.3 shall not be additionally required to be lined.

10.2 Fittings.

10.2.1 Standard Fittings. Fittings shall meet the standards in Table 10.2.1(a) or shall be in accordance with 10.2.2. In addition to the standards in Table 10.2.1(a), CPVC fittings shall also be in accordance with 10.2.2 and with the portions of the ASTM standards specified in Table 10.2.1(b) that apply to fire protection service.

Table 10.2.1(a) Fittings Materials and Dimensions

Materials and Dimensions	Standard
Cast Iron	
Cast Iron Threaded Fittings, Class 125 and 250	ASME B16.4
Cast Iron Pipe Flanges and Flanged Fittings	ASME B16.1
Malleable Iron	
Malleable Iron Threaded Fittings, Class 150 and 300	ASME B16.3
Steel	
Factory-Made Wrought Steel Buttweld Fittings	ASME B16.9
Buttwelding Ends for Pipe, Valves, Flanges, and Fittings	ASME B16.25
Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures	ASTM A 234
Steel Pipe Flanges and Flanged Fittings	ASME B16.5
Forged Steel Fittings, Socket Welded and Threaded	ASME B16.11
Copper	
Wrought Copper and Bronze Solder Joint Pressure Fittings	ASME B16.22
Cast Bronze Solder Joint Pressure Fittings	ASME B16.18

Table 10.2.1(b) Specially Listed Fittings Materials and Dimensions

Materials and Dimensions	Standard
Chlorinated Polyvinyl Chloride (CPVC) Specification for Schedule 80 CPVC Threaded Fittings	ASTM F 437
Specification for Schedule 40 CPVC Socket-Type Fittings	ASTM F 438
Specification for Schedule 80 CPVC Socket-Type Fittings	ASTM F 439

10.2.2 Special Listed Fittings. Other types of fittings investigated for suitability in automatic sprinkler installations and listed for this service including, but not limited to, polybutylene, CPVC, and steel differing from that provided in Table 10.2.1(a), and shall be permitted when installed in accordance with their listing limitations, including installation instructions.

10.2.3 Pressure Limits. Listed fittings shall be permitted for system pressures as specified in their listings, but not less than 150 psi (10 bar).

10.2.4* Buried Joints. Joints shall be approved.

10.2.5* Buried Fittings. Fittings shall be of an approved type with joints and pressure class ratings compatible with the pipe used.

10.3 Joining of Pipe and Fittings.

10.3.1 Threaded Pipe and Fittings. All threaded steel pipe and fittings shall have threads cut in accordance with ASME B1.20.1, *Pipe Threads, General Purpose (Inch).*

10.3.2 Welded Pipe and Fittings. Welding methods that comply with the applicable requirements of AWS B2.1, *Specification for Welding Procedure and Performance Qualification,* shall be permitted as means of joining steel piping.

10.3.3 Groove Joining Methods. Pipes joined with grooved fittings shall be joined by a listed combination of fittings, gaskets, and grooves.

10.3.4 Brazed and Pressure Fitting Methods. Joints for the connection of copper tube shall be brazed or joined using pressure fittings as specified in Table 10.2.1(a).

10.3.5 Other Joining Methods. Other joining methods listed for this service shall be permitted where installed in accordance with their listing limitations.

10.3.6 Pipe Joint Assembly.

10.3.6.1 Joints shall be assembled by persons familiar with the particular materials being used and in accordance with the manufacturer's instructions and specifications.

10.3.6.2 All bolted joint accessories shall be cleaned and thoroughly coated with asphalt or other corrosion-retarding material after installation.

10.4 Depth of Cover.

10.4.1* The depth of cover over water pipes shall be determined by the maximum depth of frost penetration in the locality where the pipe is laid.

10.4.2 The top of the pipe shall be buried not less than 1 ft (0.3 m) below the frost line for the locality.

10.4.3 In those locations where frost is not a factor, the depth of cover shall be not less than 2½ ft (0.8 m) to prevent mechanical damage.

10.4.4 Pipe under driveways shall be buried a minimum of 3 ft (0.9 m).

10.4.5 Pipe under railroad tracks shall be buried at a minimum of 4 ft (1.2 m).

10.4.6 The depth of cover shall be measured from the top of the pipe to finished grade, and due consideration shall always be given to future or final grade and nature of soil.

10.5 Protection Against Freezing.

10.5.1* Where it is impracticable to bury pipe, pipe shall be permitted to be laid aboveground, provided the pipe is protected against freezing and mechanical damage.

10.5.2 Pipe shall be buried below the frost line where entering streams and other bodies of water.

10.5.3 Where pipe is laid in water raceways or shallow streams, care shall be taken that there will be sufficient depth of running water between the pipe and the frost line during all seasons of frost; a safer method is to bury the pipe 1 ft (0.3048 m) or more under the bed of the waterway.

10.5.4 Pipe shall be located at a distance from stream banks and embankment walls that prevents danger of freezing through the side of the bank.

10.6 Protection Against Damage.

10.6.1 Pipe shall not be run under buildings.

10.6.2 When pipe must be run under buildings, special precautions shall be taken, including the following:

(1) Arching the foundation walls over the pipe
(2) Running pipe in covered trenches
(3) Providing valves to isolate sections of pipe under buildings

10.6.3 Fire service mains shall be permitted to enter the building adjacent to the foundation.

10.6.4 Where adjacent structures or physical conditions make it impractical to locate risers immediately inside an exterior wall, such risers shall be permitted to be located as close as practical to exterior walls to minimize underground piping under the building.

10.6.5 Where a riser is close to building foundations, underground fittings of proper design and type shall be used to avoid pipe joints being located in or under the foundations.

10.6.6 Mains shall be subjected to an evaluation of the following specific loading conditions and protected, if necessary:

(1) Mains running under railroads carrying heavy cargo
(2) Mains running under large piles of heavy commodities
(3) Mains located in areas that subject the main to heavy shock and vibrations

10.6.7* When it is necessary to join metal pipe with pipe of dissimilar metal, the joint shall be insulated against the passage of an electric current using an approved method.

10.6.8 In no case shall pipe specified in 10.6.7 be used for grounding of electrical services.

10.7 Requirement for Laying Pipe.

10.7.1 Pipes, valves, hydrants, and fittings shall be inspected for damage when received and shall be inspected prior to installation.

10.7.2 The torquing of bolted joints shall be checked.

10.7.3 Pipe, valves, hydrants, and fittings shall be clean inside.

10.7.4 When work is stopped, the open ends of pipe, valves, hydrants, and fittings shall be plugged to prevent stones and foreign materials from entering.

10.7.5 All pipe, fittings, valves, and hydrants shall be carefully lowered into the trench using appropriate equipment and carefully examined for cracks or other defects while suspended above the trench.

10.7.6 Plain ends shall be inspected for signs of damage prior to installation.

10.7.7 Under no circumstances shall water main materials be dropped or dumped.

10.7.8 Pipe shall not be rolled or skidded against other pipe materials.

10.7.9 Pipes shall bear throughout their full length and shall not be supported by the bell ends only or by blocks.

10.7.10 If ground is soft, or of a quicksand nature, special provisions shall be made for supporting pipe.

10.7.11 Valves and fittings used with nonmetallic pipe shall be properly supported and restrained in accordance with the manufacturer's specifications.

10.8 Joint Restraint.

10.8.1 General.

10.8.1.1* All tees, plugs, caps, bends, reducers, valves, and hydrant branches shall be restrained against movement by using thrust blocks in accordance with 10.8.2 or restrained joint systems in accordance with 10.8.3.

10.8.1.2 Piping with fused, threaded, grooved or welded joints shall not require additional restraining, provided that such joints can pass the hydrostatic test of 10.10.2.2 without shifting of piping or leakage in excess of permitted amounts.

10.8.1.3 Steep Grades. On steep grades, mains shall be additionally restrained to prevent slipping.

10.8.1.3.1 Pipe shall be restrained at the bottom of a hill and at any turns (lateral or vertical).

10.8.1.3.2 The restraint specified in 10.8.1.3.1 shall be to natural rock or to suitable piers built on the downhill side of the bell.

10.8.1.3.3 Bell ends shall be installed facing uphill.

10.8.1.3.4 Straight runs on hills shall be restrained as determined by the design engineer.

10.8.2* Thrust Blocks.

10.8.2.1 Thrust blocks shall be considered satisfactory where soil is suitable for their use.

10.8.2.2 Thrust blocks shall be of a concrete mix not leaner than one part cement, two and one-half parts sand, and five parts stone.

10.8.2.3 Thrust blocks shall be placed between undisturbed earth and the fitting to be restrained and shall be capable of such bearing to ensure adequate resistance to the thrust to be encountered.

10.8.2.4 Wherever possible, thrust blocks shall be placed so that the joints are accessible for repair.

10.8.3 Restrained Joint Systems. Fire mains utilizing restrained joint systems shall include the following:

(1) Locking mechanical or push-on joints
(2) Mechanical joints utilizing setscrew retainer glands
(3) Bolted flange joints
(4) Heat-fused or welded joints
(5) Pipe clamps and tie rods
(6) Other approved methods or devices

10.8.3.1 Sizing Clamps, Rods, Bolts, and Washers.

10.8.3.1.1 Clamps.

10.8.3.1.1.1 Clamps shall have the following dimensions:

(1) ½ in. × 2 in. (12.7 mm × 50.8 mm) for pipe 4 in. to 6 in.
(2) ⅝ in. × 2½ in. (15.9 mm × 63.5 mm) for pipe 8 in. to 10 in.
(3) ⅝ in. × 3 in. (15.9 mm × 76.2 mm) for 12-in. pipe

10.8.3.1.1.2 The diameter of a bolt hole shall be 1⁄16 in. (1.6 mm) larger than that of the corresponding bolts.

10.8.3.1.2 Rods.

10.8.3.1.2.1 Rods shall be not less than ⅝ in. (15.9 mm) in diameter.

10.8.3.1.2.2 Table 10.8.3.1.2.2 provides numbers of various diameter rods that shall be used for a given pipe size.

Table 10.8.3.1.2.2 Rod Number — Diameter Combinations

Nominal Pipe Size (in.)	⅝ in. (15.9 mm)	¾ in. (19.1 mm)	⅞ in. (22.2 mm)	1 in. (25.4 mm)
4	2	—	—	—
6	2	—	—	—
8	3	2	—	—
10	4	3	2	—
12	6	4	3	2
14	8	5	4	3
16	10	7	5	4

Note: This table has been derived using pressure of 225 psi (15.5 bar) and design stress of 25,000 psi (172.4 MPa).

10.8.3.1.2.3 When using bolting rods, the diameter of mechanical joint bolts shall limit the diameter of rods to ¾ in. (19.1 mm).

10.8.3.1.2.4 Threaded sections of rods shall not be formed or bent.

10.8.3.1.2.5 Where using clamps, rods shall be used in pairs for each clamp.

10.8.3.1.2.6 Assemblies in which a restraint is made by means of two clamps canted on the barrel of the pipe shall be permitted to use one rod per clamp if approved for the specific installation by the authority having jurisdiction.

10.8.3.1.2.7 Where using combinations of rods in numbers greater than two, the rods shall be symmetrically spaced.

10.8.3.1.3 Clamp Bolts. Clamp bolts shall have the following diameters:

(1) ⅝ in. (15.9 mm) for pipe 4 in., 6 in., and 8 in.
(2) ¾ in. (19.1 mm) for pipe 10 in.
(3) ⅞ in. (22.2 mm) for 12-in. pipe

10.8.3.1.4 Washers.

10.8.3.1.4.1 Washers shall be permitted to be cast iron or steel and round or square.

10.8.3.1.4.2 Cast-iron washers shall have the following dimensions:

(1) ⅝ in. × 3 in. (15.9 mm × 76.2 mm) for 4-in., 6-in., 8-in., and 10-in. pipe
(2) ¾ in. × 3½ in. (19.1 mm × 88.9 mm) for 12-in. pipe

10.8.3.1.4.3 Steel washers shall have the following dimensions:

(1) ½ in. × 3 in. (12.7 mm × 76.2 mm) for 4-in., 6-in., 8-in., and 10-in. pipe
(2) ½ in. × 3½ in. (12.7 mm × 88.9 mm) for 12-in. pipe

10.8.3.1.4.4 The diameter of holes shall be ⅛ in. (3.2 mm) larger than that of rods.

10.8.3.2 Sizes of Restraint Straps for Tees.

10.8.3.2.1 Restraint straps for tees shall have the following dimensions:

(1) ⅝ in. (15.9 mm) thick and 2½ in. (63.5 mm) wide for 4-in., 6-in., 8-in., and 10-in. pipe
(2) ⅝ in. (15.9 mm) thick and 3 in. (76.2 mm) wide for 12-in. pipe

10.8.3.2.2 The diameter of rod holes shall be 1⁄16 in. (1.6 mm) larger than that of rods.

10.8.3.2.3 Figure 10.8.3.2.3 and Table 10.8.3.2.3 shall be used in sizing the restraint straps for both mechanical and push-on joint tee fittings.

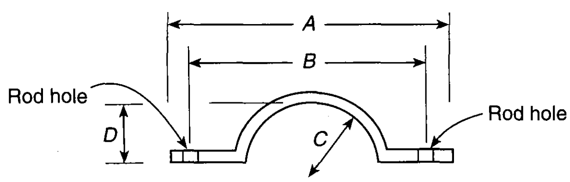


FIGURE 10.8.3.2.3 Restraint Straps for Tees.

10.8.3.3 Sizes of Plug Strap for Bell End of Pipe.

10.8.3.3.1 Strap shall be ¾ in. (19.1 mm) thick and 2½ in. (63.5 mm) wide.

10.8.3.3.2 The strap length shall be the same as dimension *A* for tee straps as shown in Figure 10.8.3.2.3.

10.8.3.3.3 The distance between the centers of rod holes shall be the same as dimension *B* for tee straps as shown in Figure 10.8.3.2.3.

10.8.3.4 Material. Clamps, rods, rod couplings or turnbuckles, bolts, washers, restraint straps, and plug straps shall be of a material that has physical and chemical characteristics that indicate its deterioration under stress can be predicted with reliability.

10.8.3.5* Corrosion Resistance. After installation, rods, nuts, bolts, washers, clamps, and other restraining devices shall be cleaned and thoroughly coated with a bituminous or other acceptable corrosion-retarding material.

10.9 Backfilling.

10.9.1 Backfill shall be tamped in layers or puddled under and around pipes to prevent settlement or lateral movement and shall contain no ashes, cinders, refuse, organic matter, or other corrosive materials.

10.9.2 Rocks shall not be placed in trenches.

10.9.3 Frozen earth shall not be used for backfilling.

10.9.4 In trenches cut through rock, tamped backfill shall be used for at least 6 in. (150 mm) under and around the pipe and for at least 2 ft (0.6 m) above the pipe.

10.10 Testing and Acceptance.

10.10.1 Approval of Underground Piping. The installing contractor shall do the following:

(1) Notifying the authority having jurisdiction and the owner's representative of the time and date testing is to be performed
(2) Performing all required acceptance tests
(3) Completing and signing the contractor's material and test certificate(s) shown in Figure 10.10.1.

10.10.2 Acceptance Requirements.

10.10.2.1* Flushing of Piping.

10.10.2.1.1 Underground piping, from the water supply to the system riser, and lead-in connections to system riser shall be completely flushed before connection is made to downstream fire protection system piping.

10.10.2.1.2 The flushing operation shall be continued for a sufficient time to ensure thorough cleaning.

10.10.2.1.3 The minimum rate of flow shall be not less than one of the following:

(1) Hydraulically calculated water demand rate of the system, including any hose requirements
(2) Flow necessary to provide a velocity of 10 ft/sec (3.1 m/sec) in accordance with Table 10.10.2.1.3
(3) Maximum flow rate available to the system under fire conditions

10.10.2.2 Hydrostatic Test.

10.10.2.2.1* All piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bar) or 50 psi (3.5 bar) in excess of the system working pressure, whichever is greater, and shall maintain that pressure without loss for 2 hours.

Table 10.8.3.2.3 Restraint Straps for Tees

	A		B		C		D	
Nominal Pipe Size (in.)	in.	mm	in.	mm	in.	mm	in.	mm
4	12½	318	10⅛	257	2½	64	1¾	44
6	14½	368	12⅛	308	3⁹⁄16	90	2¹³⁄16	71
8	16¾	425	14⅜	365	4²¹⁄32	118	3²⁹⁄32	99
10	19¹⁄16	484	16¹¹⁄16	424	5¾	146	5	127
12	22⁵⁄16	567	19⁹⁄16	487	6¾	171	5⅞	149

Contractor's Material and Test Certificate for Underground Piping

PROCEDURE

Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.

Property name	Date
Property address	

Plans	Accepted by approving authorities (names)
	Address
	Installation conforms to accepted plans ☐ Yes ☐ No Equipment used is approved ☐ Yes ☐ No If no, state deviations
Instructions	Has person in charge of fire equipment been instructed as to location of control valves and care and maintenance of this new equipment? ☐ Yes ☐ No If no, explain
	Have copies of appropriate instructions and care and maintenance charts been left on premises? ☐ Yes ☐ No If no, explain
Location	Supplies buildings
Underground pipes and joints	Pipe types and class / Type joint
	Pipe conforms to ________ standard ☐ Yes ☐ No Fittings conform to ________ standard ☐ Yes ☐ No If no, explain
	Joints needed anchorage clamped, strapped, or blocked in accordance with ________ standard ☐ Yes ☐ No If no, explain
Test description	Flushing: Flow the required rate until water is clear as indicated by no collection of foreign material in burlap bags at outlets such as hydrants and blow-offs. Flush at flows not less than 390 gpm (1476 L/min) for 4-in. pipe, 880 gpm (3331 L/min) for 6-in. pipe, 1560 gpm (5905 L/min) for 8-in. pipe, 2440 gpm (9235 L/min) for 10-in. pipe, and 3520 gpm (13,323 L/min) for 12-in. pipe. When supply cannot produce stipulated flow rates, obtain maximum available. Hydrostatic: Hydrostatic tests shall be made at not less than 200 psi (13.8 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.3 bar) for 2 hours. Leakage: New pipe laid with rubber gasketed joints shall, if the workmanship is satisfactory, have little or no leakage at the joints. The amount of leakage at the joints shall not exceed 2 quarts per hour (1.89 L/hr) per 100 joints irrespective of pipe diameter. The leakage shall be distributed over all joints. If such leakage occurs at a few joints, the installation shall be considered unsatisfactory and necessary repairs made. The amount of allowable leakage specified above can be increased by 1 fluid ounce per inch valve diameter per hr. (30 mL/25 mm/hr) for each metal seated valve isolating the test section. If dry barrel hydrants are tested with the main valve open so the hydrants are under pressure, an additional 5 ounces per minute (150 mL/min) leakage is permitted for each hydrant.
Flushing tests	New underground piping flushed according to ________ standard by (company) ☐ Yes ☐ No If no, explain
	How flushing flow was obtained: ☐ Public water ☐ Tank or reservoir ☐ Fire pump Through what type opening: ☐ Hydrant butt ☐ Open pipe
	Lead-ins flushed according to ________ standard by (company) ☐ Yes ☐ No If no, explain
	How flushing flow was obtained: ☐ Public water ☐ Tank or reservoir ☐ Fire pump Through what type opening: ☐ Y connection to flange and spigot ☐ Open pipe

FIGURE 10.10.1 Sample of Contractor's Material and Test Certificate for Underground Piping.

Hydrostatic test	All new underground piping hydrostatically tested at ______ psi for ______ hours		Joints covered ☐ Yes ☐ No
Leakage test	Total amount of leakage measured ______ gallons ______ hours		
	Allowable leakage ______ gallons ______ hours		
Hydrants	Number installed	Type and make	All operate satisfactorily ☐ Yes ☐ No
Control valves	Water control valves left wide open If no, state reason		☐ Yes ☐ No
	Hose threads of fire department connections and hydrants interchangeable with those of fire department answering alarm		☐ Yes ☐ No
Remarks	Date left in service		
Signatures	Name of installing contractor		
	Tests witnessed by		
	For property owner (signed)	Title	Date
	For installing contractor (signed)	Title	Date
Additional explanation and notes			

FIGURE 10.10.1 *Continued*

Table 10.10.2.1.3 Flow Required to Produce a Velocity of 10 ft/sec (3 m/sec) in Pipes

Pipe Size		Flow Rate	
in.	**mm**	**gpm**	**L/min**
4	102	390	1,476
6	152	880	3,331
8	203	1,560	5,905
10	254	2,440	9,235
12	305	3,520	13,323

10.10.2.2.2 Loss shall be determined by a drop in gauge pressure or visual leakage.

10.10.2.2.3 The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

10.10.2.2.4 The permitted amount of underground piping leakage shall be as follows:

(1)*The amount of leakage at the joints shall not exceed 2 qt/hr (1.89 L/hr) per 100 gaskets or joints, irrespective of pipe diameter.

(2)*The amount of allowable leakage specified in 10.10.2.2.4(1) shall be permitted to be increased by 1 fl oz (30 ml) per inch valve diameter per hour for each metal-seated valve isolating the test section.

(3) If dry barrel hydrants are tested with the main valve open so the hydrants are under pressure, an additional 5 fl oz/min (150 ml/min) of leakage shall be permitted for each hydrant.

(4) The amount of leakage in buried piping shall be measured at the specified test pressure by pumping from a calibrated container.

Chapter 11 Design Approaches

11.1 General.

11.1.1 Water demand requirements shall be determined from the following:

(1) Occupancy hazard fire control approach
(2) Storage design approaches of Chapter 12
(3) Special design approaches of Chapter 13

11.1.2 For buildings with two or more adjacent occupancies that are not physically separated by a barrier or partition capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area, the required sprinkler protection for the more demanding occupancy shall extend 15 ft (4.6 m) beyond its perimeter.

11.2 Occupancy Hazard Fire Control Approach.

11.2.1 Occupancy Classifications.

11.2.1.1 Occupancy classifications for this standard relate to sprinkler installations and their water supplies only.

11.2.1.2 Occupancy classifications shall not be used as a general classification of occupancy hazards.

11.2.1.3 Occupancies or portions of occupancies shall be classified according to the quantity and combustibility of contents, the expected rates of heat release, the total potential for energy release, the heights of stockpiles, and the presence of flammable and combustible liquids, using the definitions contained in Sections 5.2 through 5.5. Classifications are as follows:

(1) Light hazard
(2) Ordinary hazard (Groups 1 and 2)
(3) Extra hazard (Groups 1 and 2)
(4) Special occupancy hazard *(see Chapter 13)*

11.2.2 Water Demand Requirements — Pipe Schedule Method.

11.2.2.1 Table 11.2.2.1 shall be used in determining the minimum water supply requirements for light and ordinary hazard occupancies protected by systems with pipe sized according to the pipe schedules of Section 14.5.

Table 11.2.2.1 Water Supply Requirements for Pipe Schedule Sprinkler Systems

Occupancy Classification	Minimum Residual Pressure Required (psi)	Acceptable Flow at Base of Riser (Including Hose Stream Allowance) (gpm)	Duration (minutes)
Light hazard	15	500–750	30–60
Ordinary hazard	20	850–1500	60–90

Note: For SI units, 1 gpm = 3.785 L/min; 1 psi = 0.0689 bar.

11.2.2.2 Pressure and flow requirements for extra hazard occupancies shall be based on the hydraulic calculation methods of 11.2.3.

11.2.2.3 Unless the requirements of 11.2.2.5 are met the pipe schedule method shall be permitted only for new installations of 5000 ft^2 (465 m^2) or less or for additions or modifications to existing pipe schedule systems sized according to the pipe schedules of Section 14.5.

11.2.2.4 Table 11.2.2.1 shall be used in determining the minimum water supply requirements.

11.2.2.5 The pipe schedule method shall be permitted for use in systems exceeding 5000 ft^2 (465 m^2) where the flows required in Table 11.2.2.1 are available at a minimum residual pressure of 50 psi (3.4 bar) at the highest elevation of sprinkler.

11.2.2.6 The pipe schedule method shall be permitted for additions or modifications to existing extra hazard pipe schedule systems.

11.2.2.7 The lower duration value of Table 11.2.2.1 shall be acceptable only where remote station or central station waterflow alarm service is provided.

11.2.2.8* Residual Pressure.

11.2.2.8.1 The residual pressure requirement of Table 11.2.2.1 shall be met at the elevation of the highest sprinkler.

11.2.2.8.2 When backflow prevention valves are installed on pipe schedule systems, the friction losses of the device shall be accounted for when determining acceptable residual pressure at the top level of sprinklers. The friction loss of this device [in psi (bar)] shall be added to the elevation loss and the residual pressure at the top row of sprinklers to determine the total pressure needed at the water supply.

11.2.2.9 The lower flow figure of Table 11.2.2.1 shall be permitted only where the building is of noncombustible construction or the potential areas of fire are limited by building size or compartmentation such that no open areas exceed 3000 ft^2 (279 m^2) for light hazard or 4000 ft^2 (372 m^2) for ordinary hazard.

11.2.3 Water Demand Requirements — Hydraulic Calculation Methods.

11.2.3.1 General.

11.2.3.1.1* The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 11.2.3.1.1 to the water supply for sprinklers determined in 11.2.3.1.5.

Table 11.2.3.1.1 Hose Stream Demand and Water Supply Duration Requirements for Hydraulically Calculated Systems

Occupancy	Inside Hose (gpm)	Total Combined Inside and Outside Hose (gpm)	Duration (minutes)
Light hazard	0, 50, or 100	100	30
Ordinary hazard	0, 50, or 100	250	60–90
Extra hazard	0, 50, or 100	500	90–120

For SI units, 1 gpm = 3.785 L/min.

11.2.3.1.2 The minimum water supply shall be available for the minimum duration specified in Table 11.2.3.1.1.

11.2.3.1.3 An allowance for inside and outside hose shall not be required where tanks supply sprinklers only.

11.2.3.1.4 Where pumps taking suction from a private fire service main supply sprinklers only, the pump need not be sized to accommodate inside and outside hose. Such hose allowance shall be considered in evaluating the available water supplies.

11.2.3.1.5 Density/Area Curves. The water supply for sprinklers only shall be determined either from the density/area curves of Figure 11.2.3.1.5 in accordance with the method of 11.2.3.2 or be based upon the room design method in accordance with 11.2.3.3, at the discretion of the designer.

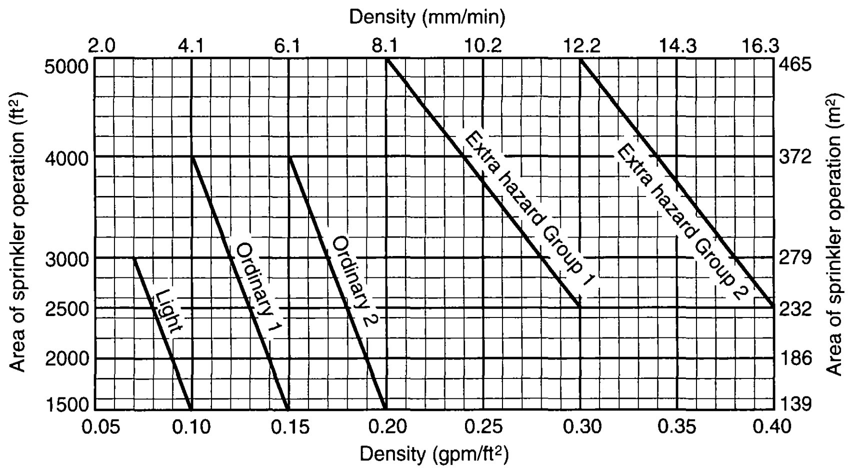


FIGURE 11.2.3.1.5 Density/Area Curves.

11.2.3.1.6 Special Areas. For special areas under consideration, as described in 11.2.3.4, separate hydraulic calculations shall be required in addition to those required by 11.2.3.2 or 11.2.3.3.

11.2.3.1.7* Systems with Multiple Hazard Classifications. For systems with multiple hazard classifications, the hose stream demand shall be in accordance with one of the following:

(1) Add the hose demand for the highest hazard classification within the system, or
(2) Add the hose demand for each individual hazard classification to the calculations for the design area for that hazard, or
(3) For systems with multiple hazard classifications where the higher classification only lies within single rooms less than or equal to 400 ft^2 in area with no such rooms adjacent, add the hose demand for the principal occupancy for the remainder of the system.

11.2.3.1.8 Restrictions. Regardless of which of the two methods is used, the following restrictions shall apply:

(1) For areas of sprinkler operation less than 1500 ft^2 (139 m^2) used for light and ordinary hazard occupancies, the density for 1500 ft^2 (139 m^2) shall be used.
(2) For areas of sprinkler operation less than 2500 ft^2 (232 m^2) for extra hazard occupancies, the density for 2500 ft^2 (232 m^2) shall be used.
(3)*Unless the requirements of 11.2.3.1.8(4) are met for buildings having unsprinklered combustible concealed spaces, as described in 8.14.1.2 and 8.14.6, the minimum area of sprinkler operation shall be 3000 ft^2 (279 m^2).
(4) The following unsprinklered combustible concealed spaces shall not require a minimum area of sprinkler operation of 3000 ft^2 (279 m^2):
   (a) Combustible concealed spaces filled entirely with noncombustible insulation.
   (b)*Light or ordinary hazard occupancies where noncombustible or limited combustible ceilings are directly attached to the bottom of solid wood joists so as to create enclosed joist spaces 160 ft^3 (4.5 m^3) or less in volume, including space below insulation that is laid directly on top or within the ceiling joists in an otherwise sprinklered attic.
   (c)*Concealed spaces where the exposed surfaces have a flame spread rating of 25 or less and the materials have been demonstrated to not propagate fire in the form in which they are installed in the space.
   (d) Concealed spaces over isolated small rooms not exceeding 55 ft^2 (5.1 m^2) in area.
   (e) Vertical pipe chases under 10 ft^2 (0.93 m^2), provided that in multifloor buildings the chases are firestopped at each floor using materials equivalent to the floor construction. Such pipe chases shall contain no sources of ignition, piping shall be noncombustible, and pipe penetrations at each floor shall be properly sealed.
(5) Water demand of sprinklers installed in racks or water curtains shall be added to the ceiling sprinkler water demand at the point of connection. Demands shall be balanced to the higher pressure. *(See Chapter 8.)*
(6) Water demand of sprinklers installed in concealed spaces or under obstructions such as ducts and cutting tables need not be added to ceiling demand.
(7) Where inside hose stations are planned or are required, the following shall apply:
   (a) A total water allowance of 50 gpm (189 L/min) for a single hose station installation shall be added to the sprinkler requirements.
   (b) A total water allowance of 100 gpm (378 L/min) for a multiple hose station installation shall be added to the sprinkler requirements.
   (c) The water allowance shall be added in 50-gpm (189-L/min) increments beginning at the most remote hose station, with each increment added at the pressure required by the sprinkler system design at that point.
(8) When hose valves for fire department use are attached to wet pipe sprinkler system risers in accordance with 8.16.5.2 the following shall apply:
   (a) The water supply shall not be required to be added to standpipe demand as determined from NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.*
   (b) Where the combined sprinkler system demand and hose stream allowance of Table 11.2.3.1.1 exceeds the requirements of NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* this higher demand shall be used.

(c) For partially sprinklered buildings, the sprinkler demand, not including hose stream allowance, as indicated in Table 11.2.3.1.1 shall be added to the requirements given in NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.*

(9) Water allowance for outside hose shall be added to the sprinkler and inside hose requirement at the connection to the city water main or a yard hydrant, whichever is closer to the system riser.

(10) The lower duration values in Table 11.2.3.1.1 shall be permitted where remote station or central station waterflow alarm service is provided.

(11) Where pumps, gravity tanks, or pressure tanks supply sprinklers only, requirements for inside and outside hose need not be considered in determining the size of such pumps or tanks.

(12) For all occupancies consisting of combustible wood joist or wood truss construction with members spaced less than 3 ft on center used with slopes with a pitch at or exceeding 4 in 12 (4/12) using standard spray sprinklers, sprinklers shall be quick response having pressures in accordance with the requirements of Table 8.6.2.2.1(a).

11.2.3.1.9 Total system water supply requirements shall be determined in accordance with the hydraulic calculation procedures of Section 14.4.

11.2.3.2 Density/Area Method.

11.2.3.2.1 Water Supply.

11.2.3.2.1.1* The water supply requirement for sprinklers only shall be calculated from the density/area curves of Figure 11.2.3.1.5 or from Chapter 13 where density/area criteria are specified for special occupancy hazards.

11.2.3.2.1.2 When using Figure 11.2.3.1.5, the calculations shall satisfy any single point on the appropriate density/area curve.

11.2.3.2.1.3 When using Figure 11.2.3.1.5, it shall not be necessary to meet all points on the selected curve.

11.2.3.2.2 Sprinklers.

11.2.3.2.2.1 The densities and areas provided in Figure 11.2.3.1.5 are for use only with spray sprinklers.

11.2.3.2.2.2* Quick-response sprinklers shall not be permitted for use in extra hazard occupancies.

11.2.3.2.2.3 Sidewall spray sprinklers shall be permitted for use in light hazard occupancies and where specifically listed for use in ordinary hazard Group 1 and 2 occupancies.

11.2.3.2.2.4 For extended coverage sprinklers, the minimum design area shall be that corresponding to the maximum density for the hazard in Figure 11.2.3.1.5 or the area protected by five sprinklers, whichever is greater.

11.2.3.2.2.5 Extended coverage sprinklers shall be listed with and designed for the minimum flow corresponding to the density for the smallest area of operation for the hazard as specified in Figure 11.2.3.1.5.

11.2.3.2.3 Quick-Response Sprinklers.

11.2.3.2.3.1 Where listed quick-response sprinklers, including extended coverage quick-response sprinklers, are used throughout a system or portion of a system having the same hydraulic design basis, the system area of operation shall be permitted to be reduced without revising the density as indicated in Figure 11.2.3.2.3.1 when all of the following conditions are satisfied:

(1) Wet pipe system
(2) Light hazard or ordinary hazard occupancy
(3) 20-ft (6.1-m) maximum ceiling height
(4) There are no unprotected ceiling pockets as allowed by 8.6.7 and 8.8.7 exceeding 32 ft^2

11.2.3.2.3.2 The number of sprinklers in the design area shall never be less than five.

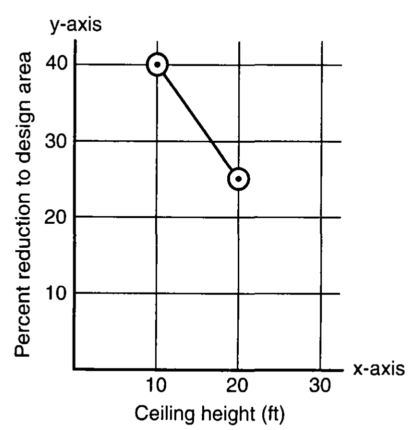
11.2.3.2.3.3 Where quick-response sprinklers are used on a sloped ceiling, the maximum ceiling height shall be used for determining the percent reduction in design area.

11.2.3.2.3.4 Where quick-response sprinklers are installed, all sprinklers within a compartment shall be of the quick-response type.

11.2.3.2.3.5 Where circumstances require the use of other than ordinary temperature–rated sprinklers, standard-response sprinklers shall be permitted to be used.

11.2.3.2.4 Sloped Ceilings in Non-Storage Applications. The system area of operation shall be increased by 30 percent without revising the density when the following types of sprinklers are used on sloped ceilings with a pitch exceeding one in six (a rise of two units in a run of 12 units, a roof slope of 16.7 percent) in non-storage applications:

(1) Spray sprinklers, including extended coverage sprinklers listed in accordance with 8.4.3(4), and quick-response sprinklers
(2) Large drop sprinklers



Note: $y = \frac{-3x}{2} + 55$

For ceiling height ≥ 10 ft and ≤ 20 ft, $y = \frac{-3x}{2} + 55$

For ceiling height < 10 ft, $y = 40$

For ceiling height > 20, $y = 0$

For SI units, 1 ft = 0.31 m.

FIGURE 11.2.3.2.3.1 Design Area Reduction for Quick-Response Sprinklers.

11.2.3.2.5 Dry Pipe and Double Interlock Preaction Systems. For dry pipe systems and double interlock preaction systems, the area of sprinkler operation shall be increased by 30 percent without revising the density.

11.2.3.2.6 High-Temperature Sprinklers. Where high-temperature sprinklers are used for extra hazard occupancies, the area of sprinkler operation shall be permitted to be reduced by 25 percent without revising the density, but not to less than 2000 ft^2 (186 m^2).

11.2.3.2.7* Multiple Adjustments.

11.2.3.2.7.1 Where multiple adjustments to the area of operation are required to be made in accordance with 11.2.3.2.4, 11.2.3.2.5, 11.2.3.2.6, or 11.2.3.2.7, these adjustments shall be compounded based on the area of operation originally selected from Figure 11.2.3.1.5.

11.2.3.2.7.2 If the building has unsprinklered combustible concealed spaces, the rules of 11.2.3.1.8 shall be applied after all other modifications have been made.

11.2.3.3 Room Design Method.

11.2.3.3.1* The water supply requirements for sprinklers only shall be based upon the room that creates the greatest demand.

11.2.3.3.2 The density selected shall be that from Figure 11.2.3.1.5 corresponding to the room size.

11.2.3.3.3 To utilize the room design method, all rooms shall be enclosed with walls having a fire-resistance rating equal to the water supply duration indicated in Table 11.2.3.1.1.

11.2.3.3.4 If the room is smaller than the smallest area shown in the applicable curve in Figure 11.2.3.1.5, the provisions of 11.2.3.1.8(1) and 11.2.3.1.8(2) shall apply.

11.2.3.3.5 Minimum protection of openings shall be as follows:

(1) Light hazard — Non-rated automatic or self-closing doors
(2) Light hazard with no opening protection — Where openings are not protected, calculations shall include the sprinklers in the room plus two sprinklers in the communicating space nearest each such unprotected opening unless the communicating space has only one sprinkler, in which case calculations shall be extended to the operation of that sprinkler. The selection of the room and communicating space sprinklers to be calculated shall be that which produces the greatest hydraulic demand.
(3) Ordinary and extra hazard — Automatic or self-closing doors with appropriate fire-resistance ratings for the enclosure

11.2.3.3.6 Where the room design method is used and the area under consideration is a corridor protected by one row of sprinklers with protected openings in accordance with 11.2.3.3.5, the maximum number of sprinklers that needs to be calculated is five.

11.2.3.3.7 Where the area under consideration is a corridor protected by a single row of sprinklers in a light hazard occupancy, the design area shall include all sprinklers in the corridor to a maximum of five.

11.2.3.3.8 Where the area under consideration is a corridor protected by a single row of sprinklers and the openings are not protected, the design area shall include all sprinklers in the corridor to a maximum of seven.

11.2.3.4 Special Design Areas.

11.2.3.4.1 Where the design area consists of a building service chute supplied by a separate riser, the maximum number of sprinklers that needs to be calculated is three.

11.2.3.4.2* Where an area is to be protected by a single line of sprinklers, the design area shall include all sprinklers on the line up to a maximum of seven.

11.2.3.5 Residential Sprinklers.

11.2.3.5.1* The design area shall be the area that includes the four hydraulically most demanding sprinklers.

11.2.3.5.2* Unless the requirements of 11.2.3.5.3 are met, the minimum required discharge from each of the four hydraulically most demanding sprinklers shall be the greater of the following:

(1) In accordance with minimum flow rates indicated in individual listings
(2) Calculated based on delivering a minimum of 0.1 gpm/ft^2 (4.1 mm/min) over the design area in accordance with the provisions of 8.5.2.1

11.2.3.5.3 For modifications or additions to existing systems equipped with residential sprinklers, the listed discharge criteria less than 0.1 gpm/ft^2 (4.1 mm/min) shall be permitted to be used.

11.2.3.5.4 Where areas such as attics, basements, or other types of occupancies are outside of dwelling units but within the same structure, these areas shall be protected in accordance with the provisions of this standard, including appropriate design criteria of 11.2.3.

11.2.3.5.5 Hose stream demand and water supply duration requirements shall be in accordance with those for light hazard occupancies in Table 11.2.3.1.1.

11.2.3.6 Quick-Response Early Suppression (QRES) Sprinklers. (Reserved)

11.2.3.7 Exposure Protection.

11.2.3.7.1* Piping shall be hydraulically calculated in accordance with Section 14.4 to furnish a minimum of 7 psi (0.5 bar) at any sprinkler with all sprinklers facing the exposure operating.

11.2.3.7.2 Where the water supply feeds other fire protection systems, it shall be capable of furnishing total demand for such systems as well as the exposure system demand.

11.2.3.8 Water Curtains.

11.2.3.8.1 Sprinklers in a water curtain such as described in 8.14.4 shall be hydraulically designed to provide a discharge of 3 gpm per lineal foot (37 L/min per lineal meter) of water curtain, with no sprinklers discharging less than 15 gpm (56.8 L/min).

11.2.3.8.2 For water curtains employing automatic sprinklers, the number of sprinklers calculated in this water curtain shall be the number in the length corresponding to the length parallel to the branch lines in the area determined by 14.4.4.1.1.

11.2.3.8.3 If a single fire can be expected to operate sprinklers within the water curtain and within the design area of a hydraulically calculated system, the water supply to the water curtain shall be added to the water demand of the hydraulic calculations and shall be balanced to the calculated area demand.

11.2.3.8.4 Hydraulic design calculations shall include a design area selected to include ceiling sprinklers adjacent to the water curtain.

11.2.3.9 Dry System Water Delivery.

11.2.3.9.1 Calculations for dry system water delivery shall be based on the hazard shown in Table 11.2.3.9.1.

11.2.3.9.2 The calculation program and method shall be listed by a nationally recognized laboratory.

Table 11.2.3.9.1 Dry System Water Delivery

Hazard	Number of Most Remote Sprinklers Initially Open	Maximum Time of Water Delivery
Residential	1	15 seconds
Light	1	60 seconds
Ordinary I	2	50 seconds
Ordinary II	2	50 seconds
Extra I	4	45 seconds
Extra II	4	45 seconds
High piled	4	40 seconds

Chapter 12 Storage

12.1 General. The requirements of Section 12.1 shall apply to all storage arrangements and commodities unless modified by specific section in Chapter 12.

12.1.1 Roof Vents and Draft Curtains. Sprinkler protection criteria are based on the assumption that roof vents and draft curtains are not being used. *(See Section C.6.)*

12.1.2 Building Height.

12.1.2.1 The maximum building height shall be measured to the underside of the roof deck or ceiling.

12.1.2.2 Early suppression fast-response (ESFR) sprinklers shall be used only in buildings equal to, or less than, the height of the building for which they have been listed.

12.1.2.3 Large drop, control mode specific application and ESFR sprinklers shall be permitted to protect ordinary hazard, storage of Class I through Class IV commodities, plastic commodities, miscellaneous storage, and other storage as specified in Chapter 12 or by other NFPA standards.

12.1.3 Hose Connections. Small hose connections [1½ in. (38 mm)] shall be provided in accordance with 8.16.5 for first-aid fire-fighting and overhaul operations.

12.1.4* Wet Pipe Systems.

12.1.4.1 Sprinkler systems shall be wet pipe systems.

12.1.4.2* In areas that are subject to freezing or where special conditions exist, dry-pipe systems and preaction systems shall be permitted to protect storage occupancies.

12.1.4.3 ESFR sprinklers shall only be permitted to be wet pipe systems.

12.1.5* Adjacent Occupancies. For buildings with two or more adjacent occupancies the following shall apply:

(1) Where areas are not physically separated by a barrier or partition capable of delaying heat from a fire in one area from fusing sprinklers in the adjacent area, the required sprinkler protection for the more demanding occupancy shall extend 15 ft (4.6 m) beyond its perimeter.
(2) The requirements of 12.1.5(1) shall not apply where the areas are separated by a barrier partition that is capable of preventing heat from a fire in the storage area from fusing sprinklers in the non-storage area.

12.1.6 Dry Pipe and Preaction Systems.

12.1.6.1 For dry pipe systems and preaction systems, the area of sprinkler operation shall be increased by 30 percent without revising the density.

12.1.6.2 Densities and areas shall be selected so that the final area of operation after the 30 percent increase is not greater than 6000 ft^2 (557.4 m^2).

12.1.6.3 The requirements of 12.1.6 shall not apply where it can be demonstrated that the detection system that activates the preaction system causes water to be discharged from sprinklers as quickly as the discharge from a wet pipe system.

12.1.7 Ceiling Slope. The sprinkler system criteria specified in this chapter are intended to apply to buildings with ceiling slopes not exceeding 2 in 12 (16.7 percent).

12.1.8* Multiple Adjustments. Where multiple adjustments to the area of operation are required to be made, these adjustments shall be compounded based on the area of operation originally selected. If the building has unsprinklered combustible concealed spaces, the rules of 11.2.3.1.8 shall be applied after all other modifications have been made.

12.1.9* Protection of Idle Pallets.

12.1.9.1 Wood Pallets.

12.1.9.1.1* Pallets shall be permitted to be stored in the following arrangements:

(1) Stored outside
(2) Stored in a detached structure
(3) Stored indoors where arranged and protected in accordance with 12.1.9.1.2

12.1.9.1.2* Pallets, where stored indoors, shall be protected as indicated in Table 12.1.9.1.2(a) using standard spray sprinklers, Table 12.1.9.1.2(b) using control mode specific application sprinklers, or Table 12.1.9.1.2(c) using ESFR sprinklers, unless the following conditions are met:

(1) Pallets shall be stored no higher than 6 ft (1.8 m).
(2) Each pallet pile of no more than four stacks shall be separated from other pallet piles by at least 8 ft (1.4 m) of clear space or 25 ft (7.6 m) of commodity.

12.1.9.1.3 Idle wood pallets shall not be stored in racks unless they are protected in accordance with the appropriate provisions of Table 12.1.9.1.2(c). *(See Section C.7.)*

Table 12.1.9.1.2(a) Control Mode Density-Area Protection of Indoor Storage of Idle Wood Pallets

Type of Sprinkler	Location of Storage	Nominal K-Factor	Maximum Storage Height		Sprinkler Density		Areas of Operation: High Temperature		Areas of Operation: Ordinary Temperature		Hose Stream Demand		Water Supply Duration (hours)
			ft	m	gpm/ft²	mm/min	ft²	m²	ft²	m²	gpm	L/min	
Control mode density/area	On floor	K 8 or larger	Up to 6	Up to 1.8	0.2	8.2	2000	186	3000	279	500	1900	1½
		K 11.2 or larger	6 to 8	1.8 to 2.4	0.45	18.3	2500	232	4000	372	500	1900	1½
			8 to 12	2.4 to 3.7	0.6	24.5	3500	325	6000	557	500	1900	1½
			12 to 20	3.7 to 6.1	0.6	24.5	4500	418	—	—	500	1900	1½

Table 12.1.9.1.2(b) Control Mode Specific Application Protection of Indoor Storage of Idle Wood Pallets

Type of Sprinkler	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Type of System	Number of Design Sprinklers by Minimum Pressure			Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m		25 psi (1.7 bar)	50 psi (3.4 bar)	75 psi (5.2 bar)	gpm	L/min	
Large drop	On floor	11.2	20	6.1	30	9.1	Wet	15	15	15	500	1900	1½
							Dry	25	25	25	500	1900	1½

Table 12.1.9.1.2(c) ESFR Protection of Indoor Storage of Idle Wood Pallets

Type of Sprinkler (Orientation)	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Minimum Operating Pressure	Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m	psi	gpm	L/min	
ESFR (pendent)	On floor or rack without solid shelves	14.0	25	7.6	30	9.1	50	250	946	1
			25	7.6	32	9.8	60			
			35	10.7	40	12.2	75			
		16.8	25	7.6	30	9.1	35			
			25	7.6	32	9.8	42			
			35	10.7	40	12.2	52			
ESFR (upright)	On floor only	14.0	20	6.1	30	9.1	50			
			20	6.1	35	10.7	75			

12.1.9.2 Plastic Pallets.

12.1.9.2.1 Plastic pallets shall be permitted to be stored in the following manners:

(1) Plastic pallets shall be permitted to be stored outside.
(2) Plastic pallets shall be permitted to be stored in a detached structure.
(3) Plastic pallets shall be permitted to be stored indoors where arranged and protected in accordance with the requirements of 12.1.9.2.2.
(4) Indoor storage of plastic pallets shall be permitted to be protected in accordance with the requirements of Table 12.1.9.2.1
(5) Indoor storage of plastic pallets shall be permitted to be protected in accordance with the following arrangement:
   (a) Maximum storage height of 10 ft
   (b) Maximum ceiling height of 30 ft
   (c) Sprinkler density 0.6 gpm/ft² over 2000 ft²
   (d) Minimum sprinkler K-factor of 16.8
(6) Indoor storage of non-wood pallets having a demonstrated fire hazard that is equal to or less than idle wood pallets and is listed for such equivalency shall be permitted to be protected in accordance with 12.1.9.1.2.
(7) When specific test data is available, the data shall take precedence in determining the required protection of idle plastic pallets.

12.1.9.2.2 Plastic pallets where stored indoors shall be protected as follows:

(1) Where stored in cutoff rooms the following shall apply:
  (a) The cutoff rooms shall have at least one exterior wall.
  (b) The plastic pallet storage shall be separated from the remainder of the building by 3 hour–rated fire walls.
  (c) Sprinkler protection by one of the following:
    i. The storage shall be protected by sprinklers designed to deliver 0.6 gpm/ft^2 (24.5 mm/min) for the entire room or by high-expansion foam and sprinklers as indicated in 12.1.11.
    ii. K-14 ESFR upright sprinklers when the storage is on floor and the system is designed to supply all sprinklers in the room at 50 psi (3.4 bar) for a maximum of 30 ft (9.1 m) ceiling or 75 psi (5.2 bar) for a maximum 35 ft (10.7 m) ceiling.
  (d) The storage shall be piled no higher than 12 ft (3.7 m).
  (e) Any steel columns shall be protected by 1-hour fireproofing or a sidewall sprinkler directed to one side of the column at the top or at the 15-ft (4.6-m) level, whichever is lower. Flow from these sprinklers shall be permitted to be omitted from the sprinkler system demand for hydraulic calculations.

(2) Where stored without cutoffs from other storage the following shall apply:
  (a) Plastic pallet storage shall be piled no higher than 4 ft (1.2 m).
  (b) Sprinkler protection shall employ high temperature–rated sprinklers.
  (c) Each pallet pile of no more than two stacks shall be separated from other pallet piles by at least 8 ft (2.4 m) of clear space or 25 ft (7.6 m) of stored commodity.

12.1.9.2.3 Idle plastic pallets shall only be stored in racks where protected in accordance with the requirements of Table 12.1.9.2.1.

12.1.10 Miscellaneous Storage and Storage of Class I through IV up to 12 ft in Height.

12.1.10.1 Discharge Criteria.

12.1.10.1.1 For protection of miscellaneous storage up to 12 ft (3.7 m) in height of Group A plastic, rubber tires, rolled paper, and storage of idle pallets up to 6 ft (1.4 m) in height, the discharge criteria in Table 12.1.10.1.1 and Figure 12.1.10 shall apply.

Table 12.1.9.2.1 ESFR Protection of Indoor Storage of Idle Plastic Pallets

Type of Sprinkler (Orientation)	Location of Storage	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m	psi	bar	gpm	L/min	
ESFR (pendent)	On floor or rack without solid shelves	14.0	25	7.6	30	9.1	50	3.4	250	946	1
			25	7.6	32	9.8	60	4.1			
			35	10.7	40	12.2	75	5.2			
		16.8	25	7.6	30	9.1	35	2.4			
			25	7.6	32	9.8	42	2.9			
			35	10.7	40	12.2	52	3.6			

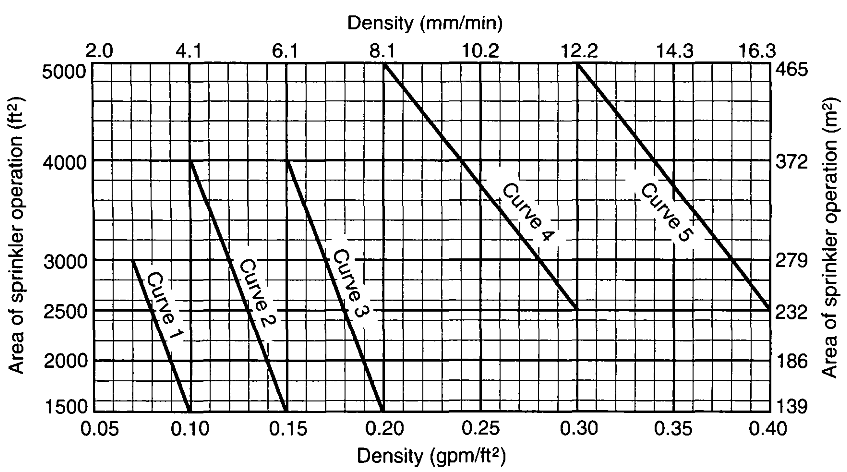


FIGURE 12.1.10 Miscellaneous Storage and Commodity Classes I through IV Storage ***12 ft (3.7 m) or Less in Height*** **— Design Curves (see Table 12.1.10.1.1).**

Table 12.1.10.1.1 Discharge Criteria for Miscellaneous Storage and Commodity Classes I through IV Storage 12 ft (3.7 m) or Less in Height[1]

Commodity		Type of Storage	Storage Height ft	Storage Height m	Maximum Ceiling Height ft	Maximum Ceiling Height m	Design Curve Figure 12.1.10	Note	Inside Hose (gpm)	Total Combined Inside and Outside Hose (gpm)	Duration (minutes)
Class I to IV											
Class I		Palletized, bin box, shelf, and rack	≤12	≤3.7	—	—	Curve 2		0, 50, or 100	250	90
Class II			≤10	≤3.05	—	—	Curve 2		0, 50, or 100	250	90
Class II			>10 to ≤12	>3.05 to ≤3.7	—	—	Curve 3		0, 50, or 100	250	90
Class III			≤12	≤3.7	—	—	Curve 3		0, 50, or 100	250	90
Class IV			≤10	≤3.05	—	—	Curve 3		0, 50, or 100	250	90
Class IV		Palletized, bin box, and shelf	>10 to ≤12	>3.05 to ≤3.7	—	—	Curve 3		0, 50, or 100	500	90
Class IV		Rack	>10 to ≤12	>3.05 to ≤3.7	—	—	Curve 4		0, 50, or 100	500	90
Miscellaneous Group A Plastic Storage											
Cartoned	Solid and expanded	Palletized, bin box, shelf, and rack	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	500	90
			>5 to ≤10	>1.5 to ≤3.05	15	4.6	Curve 4		0, 50, or 100	500	120
			>5 to ≤10	>1.5 to≤3.05	20	6.1	Curve 5		0, 50, or 100	500	120
			>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 5		0, 50, or 100	500	120
			>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
		Palletized, bin box, and shelf	>10 to ≤12	>3.05 to ≤3.7	27	8.2	Curve 5		0, 50, or 100	500	120
		Rack	>10 to ≤12	>3.05 to ≤3.7	—	—	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
Exposed	Solid and expanded	Palletized, bin box, shelf, and rack	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	500	90
		Palletized, bin box, and shelf	>5 to ≤8	>1.5 to ≤2.4	—	—	Curve 5		0, 50, or 100	500	120
		Palletized, bin box, shelf, and rack	>5 to ≤10	>1.5 to ≤3.05	15	4.6	Curve 5		0, 50, or 100	500	120

Table 12.1.10.1.1 *Continued*

Commodity		Type of Storage	Storage Height ft	Storage Height m	Maximum Ceiling Height ft	Maximum Ceiling Height m	Design Curve Figure 12.1.10	Note	Inside Hose (gpm)	Total Combined Inside and Outside Hose (gpm)	Duration (minutes)
Miscellaneous Group A Plastic Storage											
Exposed	Solid	Palletized, bin box, shelf, and rack	>5 to ≤10	>1.5 to ≤3.05	20	6.1	Curve 5		0, 50, or 100	500	120
Exposed	Expanded	Rack	>5 to ≤10	>1.5 to ≤3.05	20	6.1	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
Exposed	Solid and expanded	Palletized, bin box, and shelf	>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 5		0, 50, or 100	500	120
Exposed	Solid and expanded	Rack	>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 5		0, 50, or 100	500	120
Exposed	Solid and expanded	Rack	>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
Exposed	Solid and expanded	Rack	>10 to ≤12	>3.05 to ≤3.7	—	—	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
Miscellaneous Tire Storage											
Tires		On floor, on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 4		0, 50, or 100	750	180
Tires		On floor, on tread or on side	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	750	180
Tires		Single-, double-, or multiple-row racks on tread or on side	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	750	180
Tires		Single-row rack, portable, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 4		0, 50, or 100	750	180
Tires		Single-row rack, fixed, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 4		0, 50, or 100	750	180
Tires		Single-row rack, fixed, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 3	+ 1 level of in-rack	0, 50, or 100	750	180
Miscellaneous Rolled Paper Storage											
Heavy and medium weight		On end	≤10	≤3.05	—	—	Curve 3		0, 50, or 100	500	120
Tissue and light weight		On end	≤10	≤3.05	—	—	Curve 4		0, 50, or 100	500	120
Idle Pallet Storage											
Wooden pallets		Single-row rack, fixed	≤6	≤1.8	—	—	Curve 3		0, 50, or 100	500	90
Plastic pallets		Single-row rack, fixed	≤4	≤1.2	—	—	Curve 3		0, 50, or 100	500	90

12.1.10.1.2 For the protection of storage of Class I through IV commodities up to 12 ft (3.7 m) in height, the discharge criteria in Table 12.1.10.1.1 and Figure 12.1.10 shall apply.

12.1.10.2 Hose Stream Demand and Water Supply Duration.

12.1.10.2.1 The hose stream demand and water supply duration for the protection of palletized, solid piled, bin box, shelf storage, or rack storage of Class I through IV commodities, miscellaneous storage of Group A plastics, and miscellaneous rack storage of Class I through IV commodities, up to 12 ft (3.7 m) in height shall be in accordance with the requirements of Table 12.1.10.1.1.

12.1.10.2.2 The hose stream demand and water supply duration for the protection of miscellaneous storage of rubber tires, rolled paper, and idle pallets shall be in accordance with the requirements of Table 12.1.10.1.1.

12.1.11 High-Expansion Foam Systems.

12.1.11.1 High-expansion foam systems that are installed in addition to automatic sprinklers shall be installed in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam.*

12.1.11.2 High-expansion foam systems shall be automatic in operation.

12.1.11.3 A reduction in ceiling density to one-half that required for Class I through Class IV commodities, idle pallets, or plastics shall be permitted without revising the design area, but the density shall be no less than 0.15 gpm/ft^2 (6.1 mm/min).

12.1.11.4 High-expansion foam used to protect the idle pallet shall have a maximum fill time of 4 minutes.

12.1.12 In-Rack Sprinklers. In-rack sprinklers mandated by this standard shall meet the requirements of this section and the applicable storage protection and arrangement sections of this chapter.

12.1.12.1 Operating Pressure. In-rack sprinklers shall operate at a minimum of 15 psi (1 bar).

12.1.12.2 Water Demand. Where one level of in-rack sprinklers is installed for miscellaneous storage, water demand shall be based on simultaneous operation of the hydraulically most demanding four adjacent sprinklers.

12.1.13* Storage Applications.

12.1.13.1 For storage applications with densities of 0.20 gpm/ft^2 (8.2 mm/min) or less, standard response sprinklers with a K-factor of 5.6 or larger shall be permitted.

12.1.13.2 For general storage applications, rack storage, rubber tire storage, roll paper storage, and baled cotton storage being protected with standard upright and pendent spray sprinklers with required densities of greater than 0.20 gpm/ft^2 (8.2 mm/min) to 0.34 gpm/ft^2 (13.9 mm/min), standard response sprinklers with a nominal K-factor of 8.0 or larger shall be used.

12.1.13.3 For general storage applications, rack storage, rubber tire storage, roll paper storage, and baled cotton storage being protected with standard upright and pendent spray sprinklers with required densities greater than 0.34 gpm/ft^2 (13.9 mm/min), standard response spray sprinklers with a K-factor of 11.2 or larger that are listed for storage applications shall be used.

12.1.13.4 The requirements of 12.1.13.2 and 12.1.13.3 shall not apply to modifications to existing storage application systems, using sprinklers with K-factors of 8.0 or less.

12.1.13.5 The use of quick-response spray sprinklers for storage applications shall be permitted when listed for such use.

12.2 Fire Control Approach for the Protection of Commodities That are Stored Palletized, Solid Piled, Bin Boxes, or Shelf Storage.

12.2.1 General.

12.2.1.1 This section shall apply to a broad range of combustibles, including plastics that are stored palletized, solid piled, bin boxes, or shelf storage using standard spray sprinklers.

12.2.1.2* The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 12.2.1.2 to the water supply for sprinklers. This supply shall be available for the minimum duration specified in Table 12.2.1.2. *(See Section C.8.)*

12.2.1.2.1 An allowance for inside and outside hose shall not be required where tanks supply sprinklers only.

12.2.1.2.2 Where pumps taking suction from a private fire service main supply sprinklers only, the pump need not be sized to accommodate inside and outside hose. Such hose allowance shall be considered in evaluating the available water supplies.

12.2.1.3 High-Expansion Foam Systems.

12.2.1.3.1 A reduction in ceiling density to one-half that required for Class I through Class IV commodities, idle pallets, or plastics shall be permitted without revising the design area, but the density shall be no less than 0.15 gpm/ft^2 (6.1 mm/min).

12.2.1.3.2 Detectors for high-expansion foam systems shall be listed and shall be installed at no more than one-half the listed spacing.

12.2.1.3.3 Detection systems, concentrate pumps, generators, and other system components that are essential to the operation of the system shall have an approved standby power source.

12.2.2 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I through IV Commodities.

12.2.2.1* Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I through IV Commodities.

12.2.2.1.1 Protection for Class I through Class IV commodities in the following configurations shall be provided in accordance with this chapter:

(1) Nonencapsulated commodities that are solid pile, palletized, or bin box storage up to 30 ft (9.1 m) in height
(2) Nonencapsulated commodities on shelf storage up to 15 ft (4.6 m) in height
(3)*Encapsulated commodities that are solid pile, palletized, bin box, or shelf storage up to 15 ft (4.6 m) in height

12.2.2.1.2 The area and density for the hydraulically remote area and the water supply shall be determined as specified in 12.1.10 for storage 12 ft (3.7 m) or less and Section 12.2 for storage over 12 ft (3.7 m).

Table 12.2.1.2 Hose Stream Demand and Water Supply Duration Requirements

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Class I, II, and III	Over 12 up to 20	Over 3.7 up to 6.1	0, 50, or 100	0, 190, 380	500	1900	90
	Over 20 up to 30	Over 6.1 up to 9.1	0, 50, or 100	0, 190, 380	500	1900	120
Class IV	Over 12 up to 20	Over 3.7 up to 6.1	0, 50, or 100	0, 190, 380	500	1900	120
	Over 20 up to 30	Over 6.1 up to 9.1	0, 50, or 100	0, 190, 380	500	1900	150
Group A plastic	< 5	< 1.5	0, 50, or 100	0, 190, 380	500	1900	90
	Over 5 up to 20	Over 1.5 up to 6.1	0, 50, or 100	0, 190, 380	500	1900	120
	Over 20 up to 25	Over 6.1 up to 7.6	0, 50, or 100	0, 190, 380	500	1900	150

12.2.2.1.3 Hose connections shall not be required for the protection of Class I, II, III, and IV commodities stored 12 ft (3.7 m) or less in height.

12.2.2.1.4 Minimum System Discharge Requirements.

12.2.2.1.4.1 The design density shall not be less than 0.15 gpm/ft^2 (6.1 mm/min), and the design area shall not be less than 2000 ft^2 (186 m^2) for wet systems or 2600 ft^2 (242 m^2) for dry systems for any commodity, class, or group.

12.2.2.1.4.2 The sprinkler design density for any given area of operation for a Class III or Class IV commodity, calculated in accordance with 12.2.2, shall not be less than the density for the corresponding area of operation for ordinary hazard Group 2.

12.2.2.1.5 Protection Criteria.

12.2.2.1.5.1 Where using ordinary temperature–rated sprinklers, a single point shall be selected from the appropriate commodity curve on Figure 12.2.2.1.5.1.

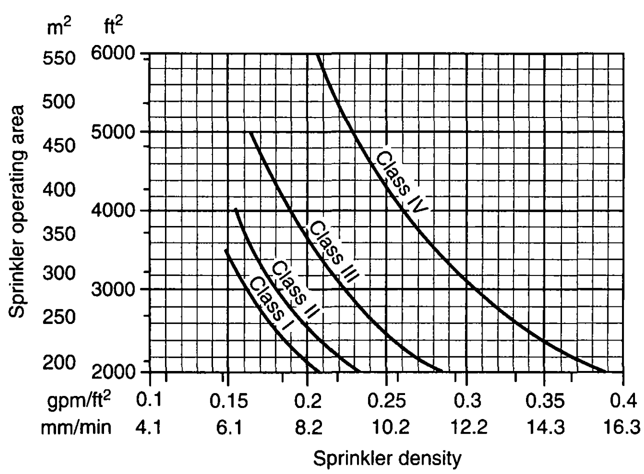


FIGURE 12.2.2.1.5.1 Sprinkler System Design Curves, 20-ft (6.1-m) High Storage — Ordinary Temperature–Rated Sprinklers.

12.2.2.1.5.2 Where using high temperature–rated sprinklers, a single point shall be selected from the appropriate commodity curve on Figure 12.2.2.1.5.2.

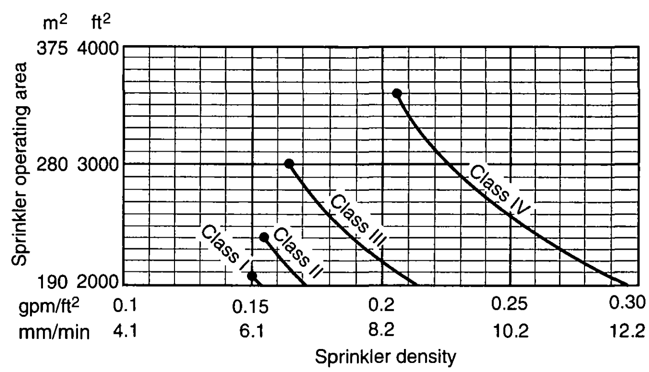


FIGURE 12.2.2.1.5.2 Sprinkler System Design Curves, 20-ft (6.1-m) High Storage — High Temperature–Rated Sprinklers.

12.2.2.1.5.3 The densities selected in accordance with 12.2.2.1.5.1 or 12.2.2.1.5.2 shall be modified in accordance with Figure 12.2.2.1.5.3 without revising the design area.

12.2.2.1.6 In the case of metal bin boxes with face areas not exceeding 16 ft^2 (1.5 m^2) and metal closed shelves with face areas not exceeding 16 ft^2 (1.5 m^2), the area of application shall be permitted to be reduced by 50 percent, provided the minimum requirements of 12.2.2.1.4 are met.

12.2.2.1.7 Ordinary- and intermediate-temperature sprinklers with K-factors of 11.2 or larger, where listed for storage, shall be permitted to use the densities from the high temperature curves of Figure 12.2.2.1.5.2.

12.2.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled Storage of Class I through IV Commodities.

12.2.2.2.1 Protection of palletized and solid-piled storage of Class I through Class IV commodities shall be in accordance with Table 12.2.2.2.1(a) and Table 12.2.2.2.1(b).

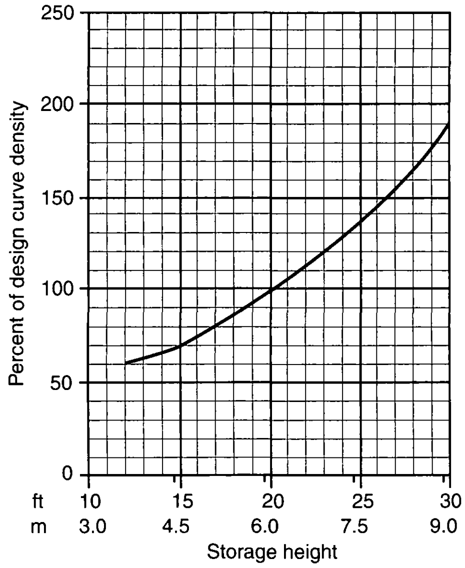


FIGURE 12.2.2.1.5.3 Ceiling Sprinkler Density vs. Storage Height.

12.2.2.2.2 Protection shall be provided as specified in Table 12.2.2.2.1(a) and Table 12.2.2.2.1(b), or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

12.2.2.2.2.1 The minimum number of design sprinklers for ordinary hazard and miscellaneous storage in accordance with this standard shall be 15 for wet pipe systems and 25 for double interlock preaction systems and dry pipe systems.

12.2.2.2.2.2 For large drop sprinkler design purposes, 95 psi (6.6 bar) shall be the maximum discharge pressure at the hydraulically most remote sprinkler.

12.2.2.2.2.3 Open Wood Joist Construction.

(A) Where large drop K-11.2 sprinklers are installed under open wood joist construction, their minimum operating pressure shall be 50 psi (3.4 bar).

(B) For large drop sprinklers, where each joist channel of open, wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 12.2.2.2.1(a) shall be permitted to be used.

Table 12.2.2.2.1(a) Large-Drop Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Class I through IV Commodities

Storage Arrangement	Commodity Class	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Type of System	Number of Design Sprinklers / Minimum Pressure		Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m		/psi	/bar	gpm	L/min	
Palletized	I, II, III	11.2	25	7.6	35	10.7	Wet	15/25	15/1.7	500	1900	2
							Dry	25/25	25/1.7	500	1900	2
	IV	11.2	20	6.1	30	9.1	Wet	20/25	20/1.7	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
		11.2	20	6.1	30	9.1	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
Solid Pile	I, II, III	11.2	20	6.1	30	9.1	Wet	15/25	15/1.7	500	1900	2
							Dry	25/25	25/1.7	N/A	N/A	N/A
	IV	11.2	20	6.1	30	9.1	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A

Table 12.2.2.2.1(b) Specific Application Control Mode (16.8 K-Factor) Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Class I through IV Commodities

Configuration	Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m		10 psi (0.7 bar)	22 psi (1.5 bar)	gpm	L/min	
Palletized	I or II	25	7.6	30	9.1	Wet	15	—	500	1900	2
Palletized	III or IV	25	7.6	30	9.1	Wet	—	15	500	1900	2
Solid pile	I or II	25	7.6	30	9.1	Wet	15	—	500	1900	1½
Solid pile	III or IV	25	7.6	30	9.1	Wet	—	15	500	1900	1½

12.2.2.2.2.4 For large drop sprinklers, the design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area protected by the number of sprinklers to be included in the design area. Any fractional sprinkler shall be included in the design area.

12.2.2.2.2.5 Hose stream demand and water supply duration requirements shall be in accordance with Table 12.2.2.2.1(a) and Table 12.2.2.2.1(b).

12.2.2.2.2.6 Preaction Systems.

(A) For the purpose of using Table 12.2.2.2.1(a) and Table 12.2.2.2.1(b), preaction systems shall be classified as dry pipe systems.

(B) Where it can be demonstrated that the detection system activating the preaction system will cause water to be at the sprinklers when they operate, preaction systems shall be permitted to be treated as wet pipe systems.

12.2.2.2.2.7 The nominal diameter of branch line pipes (including riser nipples) shall meet the following:

(1) Shall not be not less than 1¼ in. (32 mm) nor greater than 2 in. (51 mm).
(2) Starter pieces shall be permitted to be 2½ in. (64 mm).
(3) Where branch lines are larger than 2 in. (51 mm), the sprinkler shall be supplied by a riser nipple to elevate the sprinkler 13 in. (330 mm) for 2½-in. (64-mm) pipe and 15 in. (380 mm) for 3-in. (76-mm) pipe. These dimensions are measured from the centerline of the pipe to the deflector. In lieu of this, sprinklers shall be permitted to be offset horizontally a minimum of 12 in. (305 mm).

12.2.2.2.2.8 Building steel shall not require special protection where Table 12.2.2.2.1(a) and Table 12.2.2.2.1(b) are applied as appropriate for the storage configuration.

12.2.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized or Solid Piled Storage of Class I through IV Commodities.

12.2.2.3.1 Protection of palletized and solid pile storage of Classes I through IV shall be in accordance with Table 12.2.2.3.1.

12.2.2.3.2 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 12.2.2.3.1 commodity, storage height, and building height involved.

12.2.2.3.3 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines. The design shall include a minimum of 960 ft^2 (89 m^2).

12.2.2.3.4 Where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers for one of the levels shall be included with those of the other level in the hydraulic calculations.

12.2.2.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Class I through IV Commodities. Bin box and shelf storage that is over 12 ft (3.7 m) but not in excess of the height limits of 12.2.2.1 and that is provided with walkways at vertical intervals of not over 12 ft (3.7 m) shall be protected with automatic sprinklers under the walkway(s). Protection shall be as follows:

(1) Ceiling design density shall be based on the total height of storage within the building.
(2) Automatic sprinklers under walkways shall be designed to maintain a minimum discharge pressure of 15 psi (1 bar) for the most hydraulically demanding six sprinklers on each level. Walkway sprinkler demand shall not be required to be added to the ceiling sprinkler demand. Sprinklers under walkways shall not be spaced more than 8 ft (2.4 m) apart horizontally.

12.2.3 Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic and Rubber Commodities.

12.2.3.1* Control Mode Density-Area Sprinkler Protection Criteria for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic and Rubber Commodities.

12.2.3.1.1* Plastics stored up to 25 ft (7.62 m) in height protected by spray sprinklers shall be in accordance with 12.2.3.1. The decision tree shown in Figure 12.2.3.1.1 shall be used to determine the protection in each specific situation.

12.2.3.1.2* Factors affecting protection requirements such as closed/open array, clearance between storage and sprinklers, and stable/unstable piles shall be applicable only to storage of Group A plastics. This decision tree also shall be used to determine protection for commodities that are not wholly Group A plastics but contain such quantities and arrangements of the same that they are deemed more hazardous than Class IV commodities.

12.2.3.1.3 Group B plastics and free-flowing Group A plastics shall be protected in the same manner as a Class IV commodity. See 12.2.2 for protection of these storage commodities with spray sprinklers.

12.2.3.1.4 Group C plastics shall be protected in the same manner as a Class III commodity. See 12.2.2 for protection of these storage commodities with spray sprinklers.

12.2.3.1.5* Storage Conditions.

12.2.3.1.5.1 The design of the sprinkler system shall be based on those conditions that routinely or periodically exist in a building that create the greatest water demand. These conditions include the following:

(1) Pile height
(2) Clearance
(3) Pile stability
(4) Array

12.2.3.1.5.2 Where the distance between roof/ceiling height and top of storage exceeds 20 ft (6.1 m), protection shall be provided for the storage height that would result in a 20-ft (6.1-m) distance between the roof/ceiling height and top of storage.

12.2.3.1.6* Design areas and densities for the appropriate storage configuration shall be selected from Table 12.2.3.1.6. The columns A, B, C, D, and E correspond to the protection required by the decision tree shown in Figure 12.2.3.1.1.

12.2.3.1.7 For Table 12.2.3.1.6 the design areas shall be as follows:

(1) The area shall be a minimum of 2500 ft^2 (232 m^2).
(2) Where Table 12.2.3.1.6 allows densities and areas to be selected in accordance with Figure 12.1.10, Curve 3, any density-area from Curve 3 shall be permitted.
(3) For closed arrays, the area shall be permitted to be reduced to 2000 ft^2 (186 m^2).

Table 12.2.2.3.1 ESFR Protection of Palletized and Solid-Pile Storage of Class I through IV Commodities

Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
	ft	m	ft	m			psi	bar	gpm	L/min	
Class I, II, III, or IV, encapsulated (no open-top containers or solid shelves)	20	6.1	25	7.6	11.2	Upright	50	3.4	250	946	1
					14.0	Upright or pendent	50	3.4			
					16.8	Pendent	35	2.4			
					25.2	Pendent	15	1.0			
	25	7.6	30	9.1	14.0	Upright or pendent	50	3.4			
					16.8	Pendent	35	2.4			
					25.2	Pendent	15	1.0			
			32	9.8	14.0	Upright or pendent	60	4.1			
					16.8	Pendent	42	2.9			
	30	9.1	35	10.7	14.0	Upright or pendent	75	5.2			
					16.8	Pendent	52	3.6			
					25.2	Pendent	20	1.4			
	35	10.7	40	12.2	14.0	Pendent	75	5.2			
					16.8	Pendent	52	3.6			
					25.2	Pendent	25	1.7			
	35	10.7	45	13.7	25.2	Pendent	40	2.8			
	40	12.2	45	13.7	25.2	Pendent	40	2.8			

12.2.3.1.8 Interpolation of densities between storage heights shall be permitted. Densities shall be based upon the 2500 ft^2 (232 m^2) design area. The "up to" in the table is intended to aid in the interpolation of densities between storage heights. Interpolation of ceiling/roof heights shall not be permitted.

12.2.3.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Palletized or Solid Piled of Plastic and Rubber Commodities.

12.2.3.2.1 Protection of palletized and solid-piled storage of unexpanded plastic and expanded plastic commodities shall be in accordance with Table 12.2.3.2.1(a) or Table 12.2.3.2.1(b).

12.2.3.2.2 Protection shall be provided as specified in Table 12.2.3.2.1(a) and Table 12.2.3.2.1(b) or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

12.2.3.2.2.1 For design purposes, 95 psi (6.6 bar) shall be the maximum discharge pressure at the hydraulically most remote sprinkler.

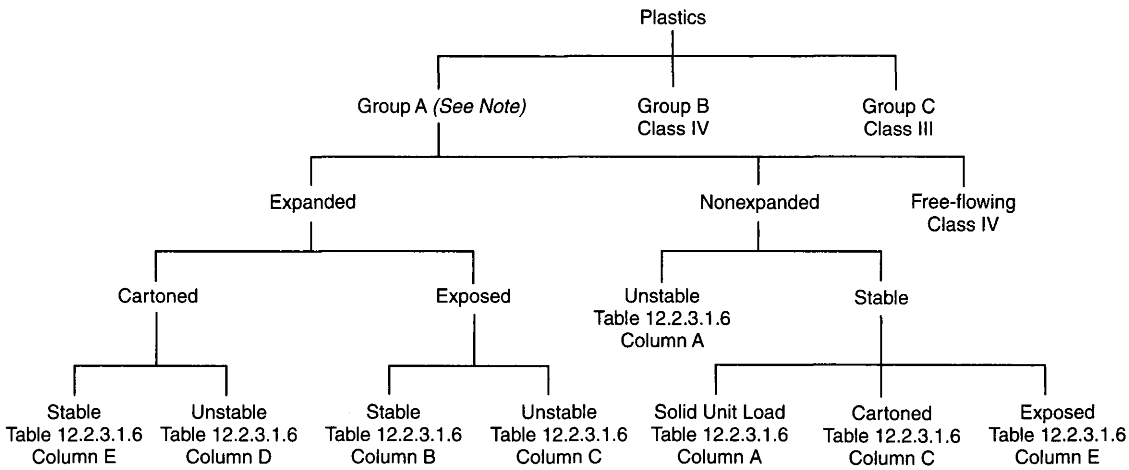
12.2.3.2.2.2 Open Wood Joist Construction.

(A) Where large drop K-11.2 sprinklers are installed under open wood joist construction, their minimum operating pressure shall be 50 psi (3.4 bar).

(B) Where each joist channel of open, wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 12.2.3.2.1(a) shall be permitted to be used.

12.2.3.2.2.3 The design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area protected by the number of sprinklers to be included in the design area. Any fractional sprinkler shall be included in the design area.

12.2.3.2.2.4 Hose stream demand and water supply duration requirements shall be in accordance with Table 12.2.3.2.1(a) and Table 12.2.3.2.1(b).



Note: Cartons that contain Group A plastic material shall be permitted to be treated as Class IV commodities under the following conditions:

(a) There shall be multiple layers of corrugation or equivalent outer material that would significantly delay fire involvement of the Group A plastic

(b) The amount and arrangement of Group A plastic material within an ordinary carton would not be expected to significantly increase the fire hazard

FIGURE 12.2.3.1.1 Decision Tree.

Table 12.2.3.1.6 Design Densities for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic and Rubber Commodities

Storage Height		Roof/Ceiling Height		Density A		Density B		Density C		Density D		Density E	
ft	m	ft	m	gpm/ft²	mm/min	gpm/ft²	mm/min	gpm/ft²	mm/min	gpm/ft²	mm/min	gpm/ft²	mm/min
≤ 5	1.52	up to 25	up to 7.62	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3	Curve 3
≤ 12	3.66	up to 15 >15 to 20 >20 to 32	up to 4.57 >4.57 to 6.1 >6.1 to 9.75	0.2 0.3 0.4	8.2 12.2 16.3	Curve 5 0.6 0.8	Curve 5 24.5 32.6	0.3 0.5 0.6	12.2 20.4 24.5	Curve 4 Curve 5 0.45	Curve 4 Curve 5 18.3	Curve 5 Curve 5 0.7	Curve 5 Curve 5 28.5
15	4.5	up to 20 >20 to 25 >25 to 35	up to 6.1 >6.1 to 7.62 >7.62 to 10.67	0.25 0.4 0.45	10.2 16.3 18.3	0.5 0.8 0.9	20.4 32.6 36.7	0.4 0.6 0.7	16.3 24.5 28.5	0.3 0.45 0.55	12.2 18.3 22.4	0.45 0.7 0.85	18.3 28.5 34.6
20	6.1	up to 25 >25 to 30 >30 to 35	up to 7.62 >7.62 to 9.14 >9.14 to 10.67	0.3 0.45 0.6	12.2 18.3 24.5	0.6 0.9 1.2	24.5 36.7 48.9	0.45 0.7 0.85	18.3 28.5 34.6	0.35 0.55 0.7	14.3 22.4 28.5	0.55 0.85 1.1	22.4 34.6 44.8
25	7.62	up to 30 >30 to 35	up to 9.14 >9.14 to 10.67	0.4 0.6	16.3 24.5	0.75 1.2	30.6 48.9	0.55 0.85	22.4 34.6	0.45 0.7	18.3 28.5	0.7 1.1	28.5 44.8

Notes:

1. Minimum clearance between sprinkler deflector and top of storage shall be maintained as required.
2. Column designations correspond to the configuration of plastics storage as follows:
   A: (1) Nonexpanded, unstable
   (2) Nonexpanded, stable, solid unit load
   B: Expanded, exposed, stable
   C: (1) Expanded, exposed, unstable
   (2) Nonexpanded, stable, cartoned
   D: Expanded, cartoned, unstable
   E: (1) Expanded, cartoned, stable
   (2) Nonexpanded, stable, exposed
3. Curve 3 = Density required by Figure 12.1.10 for Curve 3
   Curve 4 = Density required by Figure 12.1.10 for Curve 4
   Curve 5 = Density required by Figure 12.1.10 for Curve 5
4. Hose streams and durations shall be as follows: ≤5 ft 250 gpm and 90 minutes; >5 ft to ≤20 ft 500 gpm and 120 minutes, >20 ft to ≤25 ft 500 gpm and 150 minutes.

Table 12.2.3.2.1(a) Large-Drop Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Plastic and Rubber Commodities

Storage Arrangement	Commodity Class	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Type of System	Number of Design Sprinklers / Minimum Pressure		Hose Stream Demand		Water Supply Duration (hours)
			ft	m	ft	m		/psi	/bar	gpm	L/min	
Palletized	Cartoned or exposed unexpanded plastics	11.2	20	6.1	30	9.1	Wet	25/25	25/1.7	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
	Cartoned or exposed expanded plastics	11.2	18	5.5	26	7.9	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A
Solid pile	Cartoned or exposed unexpanded plastics	11.2	20	6.1	30	9.1	Wet	15/50	15/3.4	500	1900	2
							Dry	N/A	N/A	N/A	N/A	N/A

Table 12.2.3.2.1(b) Specific Application Control Mode (16.8 K-Factor) Sprinkler Design Criteria for Palletized and Solid-Piled Storage of Plastic and Rubber Commodities

Configuration	Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m		10 psi (0.7 bar)	22 psi (1.5 bar)	gpm	L/min	
Palletized	Cartoned or exposed unexpanded plastics	25	7.6	30	9.1	Wet	—	15	500	1900	2
Solid pile	Cartoned or exposed unexpanded plastics	25	7.6	30	9.1	Wet	—	15	500	1900	1½

12.2.3.2.2.5 Preaction Systems.

(A) For the purpose of using 12.2.3.2.1, preaction systems shall be classified as dry pipe systems.

(B) Where it can be demonstrated that the detection system activating the preaction system will cause water to be at the sprinklers when they operate, preaction systems shall be permitted to be treated as wet pipe systems.

12.2.3.2.2.6 The nominal diameter of branch line pipes (including riser nipples) shall meet the following:

(1) Pipe diameter shall not be not less than 1¼ in. (33 mm) nor greater than 2 in. (51 mm).
(2) Starter pieces shall be permitted to be 2½ in. (64 mm).
(3) Where branch lines are larger than 2 in. (51 mm), the sprinkler shall be supplied by a riser nipple to elevate the sprinkler 13 in. (330 mm) for 2½-in. (64-mm) pipe and 15 in. (380 mm) for 3-in. (76-mm) pipe. These dimensions are measured from the centerline of the pipe to the deflector. In lieu of this, sprinklers shall be permitted to be offset horizontally a minimum of 12 in. (305 mm).

12.2.3.2.2.7 Building steel shall not require special protection where Table 12.2.3.2.1(a) and Table 12.2.3.2.1(b) is applied as appropriate for the storage configuration.

12.2.3.3 Early Suppression Fast-Response (ESFR) Sprinklers for Palletized, Solid Piled of Plastic and Rubber Commodities.

12.2.3.3.1 Protection of palletized and solid pile storage of cartoned or uncartoned unexpanded plastic and cartoned expanded plastic shall be in accordance with Table 12.2.3.3.1.

12.2.3.3.2 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 12.2.3.3.1 for type of storage, commodity, storage height, and building height involved.

12.2.3.3.3 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines. The design shall include a minimum of 960 ft^2 (89 m^2).

12.2.3.3.4 Where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers for one of the levels shall be included with those of the other level in the hydraulic calculations.

Table 12.2.3.3.1 ESFR Protection of Palletized and Solid-Pile Storage of Plastic and Rubber Commodities

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/ Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m			psi	bar	gpm	L/min	
Palletized and solid pile storage (no open-top containers or solid shelves)	Cartoned unexpanded plastic	20	6.1	25	7.6	11.2	Upright	50	3.4	250	946	1
						14.0	Upright or pendent	50	3.4			
						16.8	Pendent	35	2.4			
						25.2	Pendent	15	1.0			
				30	9.1	14.0	Upright or pendent	50	3.4			
						16.8	Pendent	35	2.4			
						25.2	Pendent	15	1.0			
				35	7.6	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
						25.2	Pendent	20	1.4			
				40	12.2	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
						25.2	Pendent	25	1.7			
				45	13.7	25.2	Pendent	40	2.8			
		25	7.6	30	9.1	14.0	Upright or pendent	50	3.4			
						16.8	Pendent	35	2.4			
						25.2	Pendent	15	1.0			
				32	9.8	14.0	Upright or pendent	60	4.1			
						16.8	Pendent	42	2.9			
				35	7.6	14.0	Upright or pendent	75	5.2			
						16.8	Pendent	52	3.6			
						25.2	Pendent	20	1.4			
				40	12.2	14.0	Upright or pendent	75	5.2			
						16.8	Pendent	52	3.6			
						25.2	Pendent	25	1.7			
				45	13.7	25.2	Pendent	40	2.8			
		30	9.1	35	10.7	14.0	Upright or pendent	75	5.2			
						16.8	Pendent	52	3.6			
						25.2	Pendent	20	1.4			
				40	12.2	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
						25.2	Pendent	25	1.7			
				45	13.7	25.2	Pendent	40	2.8			

Table 12.2.3.3.1 *Continued*

Storage Arrangement	Commodity	Maximum Storage Height ft	Maximum Storage Height m	Maximum Ceiling/ Roof Height ft	Maximum Ceiling/ Roof Height m	Nominal K-Factor	Orientation	Minimum Operating Pressure psi	Minimum Operating Pressure bar	Hose Stream Demand gpm	Hose Stream Demand L/min	Water Supply Duration (hours)
Palletized and solid pile storage (no open-top containers or solid shelves)	Cartoned unexpanded plastic (continued)	35	10.7	40	12.2	14.0	Pendent	75	5.2	250	946	1
						16.8	Pendent	52	3.6			
						25.2	Pendent	25	1.7			
				45	13.7	25.2	Pendent	40	2.8			
		40	12.2	45	13.7	25.2	Pendent	40	2.8			
	Exposed unexpanded plastic	20	6.1	25	7.6	14.0	Pendent	50	3.4			
						16.8	Pendent	35	2.4			
				30	9.1	14.0	Pendent	50	3.4			
						16.8	Pendent	35	2.4			
				35	10.7	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
				40	12.2	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
		25	7.6	30	9.1	14.0	Pendent	50	3.4			
						16.8	Pendent	35	2.4			
				32	9.8	14.0	Pendent	60	4.1			
						16.8	Pendent	42	2.9			
				35	10.7	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
				40	12.2	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
		30	9.1	35	10.7	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
				40	12.2	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
		35	10.7	40	12.2	14.0	Pendent	75	5.2			
						16.8	Pendent	52	3.6			
	Cartoned expanded plastic	20	6.1	25	7.6	14.0	Upright or pendent	50	3.4			
						16.8	Pendent	35	2.4			
				30	9.1	14.0	Upright or pendent	50	3.4			
						16.8	Pendent	35	2.4			
		25	7.6	30	9.1	14.0	Upright or pendent	50	3.4			
						16.8	Pendent	35	2.4			
				32	9.8	14.0	Pendent	60	4.1			
						16.8	Pendent	42	2.9			

12.2.3.4 Special Design for Palletized, Solid Piled, Bin Box, or Shelf Storage of Plastic and Rubber Commodities. (Reserved)

12.3 Protection of Commodities Stored on Racks. *(See Section C.9.)*

12.3.1 Protection Criteria — General.

12.3.1.1 This section shall apply to storage of materials representing the broad range of combustibles stored in racks.

12.3.1.2* Sprinkler Protection Criteria.

12.3.1.2.1 Sprinkler protection criteria for the storage of materials on racks shall be in accordance with 12.3.2 or 12.3.3 for storage up to 25 ft (7.6 m), and 12.3.4 and 12.3.5 for storage over 25 ft (7.6 m).

12.3.1.2.2* Protection criteria for Group A plastics shall be permitted for the protection of the same storage height and configuration of Class I, II, III, and IV commodities.

12.3.1.3 Hose connections shall not be required for the protection of Class I, II, III, and IV commodities stored 12 ft (3.7 m) or less in height.

12.3.1.4 The design figures indicate water demands for ordinary temperature-rated and nominal high temperature-rated sprinklers at the ceiling. The ordinary-temperature design densities correspond to ordinary temperature-rated sprinklers and shall be used for sprinklers with ordinary- and intermediate-temperature classification. The high-temperature design densities correspond to high temperature–rated sprinklers and shall be used for sprinklers having a high temperature rating.

12.3.1.5 Ordinary- and intermediate-temperature sprinklers with K-factors of 11.2 or larger, where listed for storage, shall be permitted to use the densities for high-temperature sprinklers.

12.3.1.6 Movable Racks. Rack storage in movable racks shall be protected in the same manner as multiple-row racks.

12.3.1.7 Fire Protection of Steel Columns — Columns within Storage Racks of Class I through Class IV and Plastic Commodities. *(See Section C.10.)*

12.3.1.7.1 Where sprinkler protection of building columns within the rack structure or vertical rack members supporting the building are required in lieu of fireproofing, sprinkler protection in accordance with one of the following shall be provided:

(1) Sidewall sprinklers at the 15-ft (4.6-m) elevation, pointed toward one side of the steel column
(2) Provision of ceiling sprinkler density for a minimum of 2000 ft^2 (186 m^2) with ordinary 165°F (74°C) or high temperature 286°F (141°C) rated sprinklers as shown in Table 12.3.1.7.1 for storage heights above 15 ft (4.6 m), up to and including 20 ft (6.1 m)
(3) Provision of large drop, specific application control mode or ESFR ceiling sprinkler protection

12.3.1.7.2 The flow from a column sprinkler(s) shall be permitted to be omitted from the sprinkler system hydraulic calculations.

12.3.1.8 High-Expansion Foam.

12.3.1.8.1* Where high-expansion foam systems are installed, they shall be in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam,* and they shall be automatic in operation, unless modified by this standard.

Table 12.3.1.7.1 Ceiling Sprinkler Densities for Protection of Steel Building Columns

Commodity Classification	Aisle Width: 4 ft (1.2 m) gpm/ft^2	4 ft (1.2 m) (L/min)/m^2	8 ft (2.4 m) gpm/ft^2	8 ft (2.4 m) (L/min)/m^2
Class I	0.37	15.1	0.33	13.5
Class II	0.44	17.9	0.37	15.1
Class III	0.49	20	0.42	17.1
Class IV and Plastics	0.68	27.7	0.57	23.2

12.3.1.8.2 In-rack sprinklers shall not be required where high-expansion foam systems are used in combination with ceiling sprinklers.

12.3.1.8.3 Detectors for High-Expansion Foam Systems.

12.3.1.8.3.1 Detectors shall be listed and shall be installed in one of the following configurations:

(1) At the ceiling only where installed at one-half the listed linear spacing [e.g., 15 ft × 15 ft (4.6 m × 4.6 m) rather than at 30 ft × 30 ft (9.1 m × 9.1 m)]; at the ceiling at the listed spacing and in racks at alternate levels
(2) Where listed for rack storage installation and installed in accordance with the listing to provide response within 1 minute after ignition using an ignition source that is equivalent to that used in a rack storage testing program

12.3.1.8.3.2 Ceiling detectors alone shall not be used where the ceiling/roof clearance from the top of the storage exceeds 10 ft (3.1 m) or the height of the storage exceeds 25 ft (7.6 m).

12.3.1.8.4 Detectors for preaction systems shall be installed in accordance with 12.3.1.8.3.

12.3.1.9 Solid Shelving.

12.3.1.9.1 Where solid shelving in single-, double-, and multiple-row racks exceeds 20 ft^2 but does not exceed 64 ft^2 in area, sprinklers shall not be required below every shelf, but shall be installed at the ceiling and below shelves at intermediate levels not more than 6 ft (2 m) apart vertically. *(See Section C.11.)*

12.3.1.9.2 Where solid shelving in single-, double-, and multiple-row racks exceeds 64 ft^2 in area or where the levels of storage exceed 6 ft (2 m), sprinklers shall be installed at the ceiling and below each level of shelving.

12.3.1.10 Open-Top Combustible Containers. See Section C.12.

12.3.1.11 In-Rack Sprinklers.

12.3.1.11.1 The number of sprinklers and the pipe sizing on a line of sprinklers in racks shall be restricted only by hydraulic calculations and not by any piping schedule.

12.3.1.11.2 When in-rack sprinklers are necessary to protect a higher hazard commodity that occupies only a portion of the length of a rack, in-rack sprinklers shall be extended a minimum of 8 ft or one bay, whichever is greater, in each direction along the rack on either side of the higher hazard. The in-rack sprinklers protecting the higher hazard need not be extended across the aisle.

12.3.1.11.3 Where a storage rack, due to its length, requires less than the number of in-rack sprinklers specified, only those in-rack sprinklers in a single rack need to be included in the calculation.

12.3.1.12* Horizontal Barriers and In-Rack Sprinklers. Horizontal barriers used in conjunction with in-rack sprinklers to impede vertical fire development shall be constructed of sheet metal, wood, or similar material and shall extend the full length and width of the rack. Barriers shall be fitted within 2 in. (51 mm) horizontally around rack uprights.

12.3.1.13 For Storage Up to and Including 25 ft (7.6 m). In double-row and multiple-row racks without solid shelves, a longitudinal (back-to-back clearance between loads) flue space shall not be required. Nominal 6-in. (152.4-mm) transverse flue spaces between loads and at-rack uprights shall be maintained in single-row, double-row, and multiple-row racks. Random variations in the width of flue spaces or in their vertical alignment shall be permitted. *(See Section C.13.)*

12.3.1.14 For Storage over 25 ft (7.6 m).

12.3.1.14.1 Nominal 6-in. (152.4-mm) transverse flue spaces between loads and at rack uprights shall be maintained in single-row, double-row, and multiple-row racks. Nominal 6-in. (152.4-mm) longitudinal flue spaces shall be provided in double-row racks. Random variations in the width of the flue spaces or in their vertical alignment shall be permitted.

12.3.1.14.2 In single-row, double-row, or multiple-row racks, a minimum 6-in. (152.4-mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage. Face sprinklers in such racks shall be located a minimum of 3 in. (76 mm) from rack uprights and no more than 18 in. (460 mm) from the aisle face of storage. Longitudinal flue in-rack sprinklers shall be located at the intersection with the transverse flue space and with the deflector located at or below the bottom of horizontal load beams or above or below other adjacent horizontal rack members. Such in-rack sprinklers shall be a minimum of 3 in. (76 mm) radially from the side of the rack uprights.

12.3.2 Protection Criteria for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.1.1 The area and density for the hydraulically remote area and the water supply shall be determined as specified in 12.1.10 for storage up to 12 ft (3.7 m) and 12.3.2 for storage over 12 ft (3.7 m).

12.3.2.1.1.1* Ceiling sprinkler water demand shall be determined in accordance with 12.3.2.1.2 for single- and double-row racks or 12.3.2.1.3 for multiple-row racks. *(See Section C.14.)*

12.3.2.1.2* Single- or double-row racks for Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated in single- or double-row racks, ceiling sprinkler water demand in terms of density (gpm/ft^2) (mm/min) and area of sprinkler operation [ft^2 (m^2) of ceiling or roof] shall be selected from the density/area curves of Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(g) that are appropriate for each commodity and configuration as shown in Table 12.3.2.1.2 and shall be modified as appropriate by 12.3.2.1.5. These requirements shall apply to portable racks arranged in the same manner as single- or double-row racks.

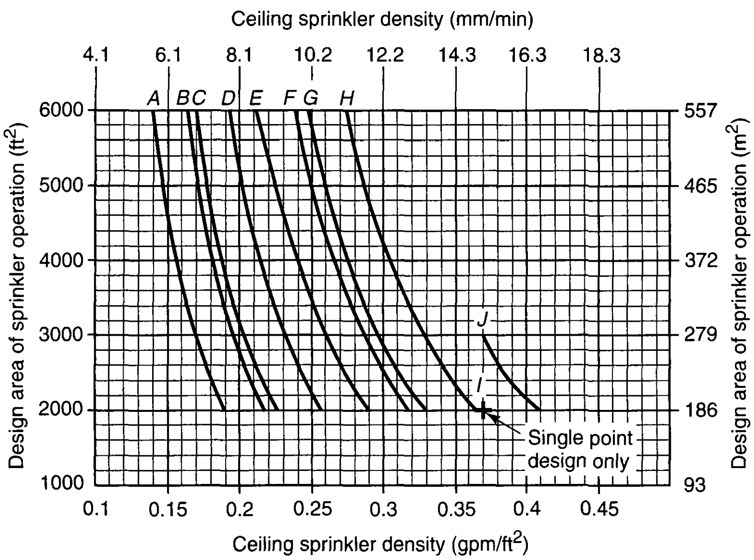
Table 12.3.2.1.2 Single- or Double-Row Racks — Storage Height Up to and Including 25 ft (7.6 m) Without Solid Shelves

						Ceiling Sprinkler Water Demand					
			Aisles*			With In-Rack Sprinklers			Without In-Rack Sprinklers		
Height	Commodity Class	Encapsulated	ft	m	Sprinklers Mandatory In-Rack	Figure	Curves	Apply Figure 12.3.2.1.5.1	Figure	Curves	Apply Figure 12.3.2.1.5.1
Over 12 ft (3.7 m), up to and including 20 ft (6.1m)	I	No	4	1.2	No	12.3.2.1.2(a)	C and D	Yes	12.3.2.1.2(a)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	No	12.3.2.1.2(e)	C and D		12.3.2.1.2(e)	G and H	Yes
			8	2.4			A and B			E and F	
	II	No	4	1.2	No	12.3.2.1.2(b)	C and D		12.3.2.1.2(b)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	No	12.3.2.1.2(e)	C and D		12.3.2.1.2(e)	G and H	Yes
			8	2.4			A and B			E and F	
	III	No	4	1.2	No	12.3.2.1.2(c)	C and D		12.3.2.1.2(c)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(f)	C and D		—	—	—
			8	2.4			A and B				
	IV	No	4	1.2	No	12.3.2.1.2(d)	C and D		12.3.2.1.2(d)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(g)	C and D		—	—	—
			8	2.4			A and B				

Table 12.3.2.1.2 *Continued*

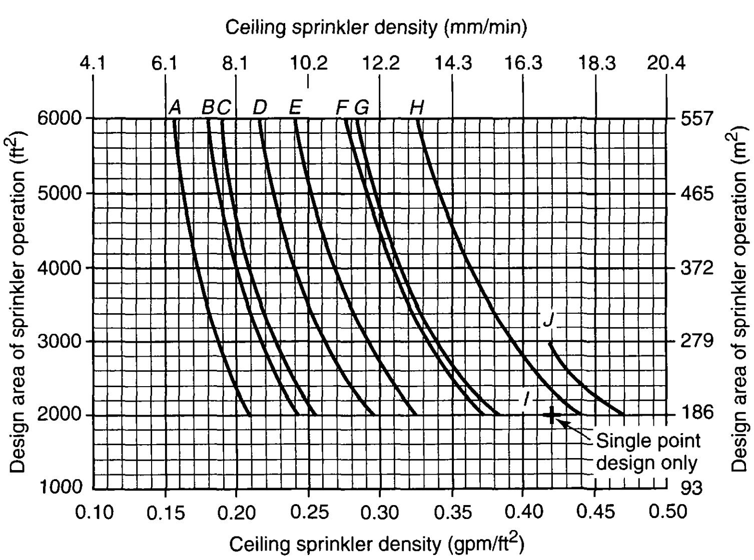
			Aisles*			Ceiling Sprinkler Water Demand					
						With In-Rack Sprinklers			Without In-Rack Sprinklers		
Height	Commodity Class	Encapsulated	ft	m	Sprinklers Mandatory In-Rack	Figure	Curves	Apply Figure 12.3.2.1.5.1	Figure	Curves	Apply Figure 12.3.2.1.5.1
Over 20 ft (6.1 m), up to and including 22 ft (6.7 m)	I	No	4	1.2	No	12.3.2.1.2(a)	C and D	No	12.3.2.1.2(a)	F and H	Yes
			8	2.4			A and B			E and G	
		Yes	4	1.2	1 level	12.3.2.1.2(e)	C and D		—	—	—
			8	2.4			A and B				
	II	No	4	1.2	No	12.3.2.1.2(b)	C and D		12.3.2.1.2(b)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(e)	C and D		—	—	—
			8	2.4			A and B				
	III	No	4	1.2	No	12.3.2.1.2(c)	C and D		12.3.2.1.2(c)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(f)	C and D		—	—	—
			8	2.4			A and B				
	IV	No	4	1.2	No	12.3.2.1.2(d)	C and D		12.3.2.1.2(d)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(g)	C and D		—	—	—
			8	2.4			A and B				
Over 22 ft (6.7 m), up to and including 25 ft (7.6 m)	I	No	4	1.2	No	12.3.2.1.2(a)	C and D	No	12.3.2.1.2(a)	F and H	Yes
			8	2.4			A and B			E and G	
		Yes	4	1.2	1 level	12.3.2.1.2(e)	C and D		—	—	—
			8	2.4			A and B				
	II	No	4	1.2	No	12.3.2.1.2(b)	C and D		12.3.2.1.2(b)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(e)	C and D		—	—	—
			8	2.4			A and B				
	III	No	4	1.2	No	12.3.2.1.2(c)	C and D		12.3.2.1.2(c)	G and H	Yes
			8	2.4			A and B			E and F	
		Yes	4	1.2	1 level	12.3.2.1.2(f)	C and D		—	—	—
			8	2.4			A and B				
	IV	No	4	1.2	1 level	12.3.2.1.2(d)	C and D		—	—	—
			8	2.4			A and B				
		Yes	4	1.2		12.3.2.1.2(g)	C and D		—	—	—
			8	2.4			A and B				

*See 12.3.2.1.2.1 for interpolation of aisle widths.



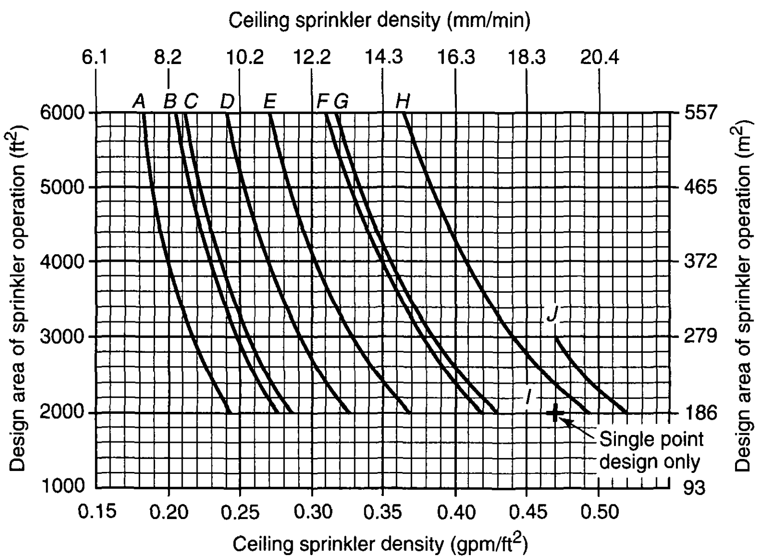
Curve	Legend
A	Single-or double-row racks with 8-ft (2.44-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
B	Single-or double-row racks with 8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
C	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
D	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
E	Single-or double-row racks with 8-ft (2.44-m) aisles and 286°F (141°C) ceiling sprinklers
F	Single-or double-row racks with 8-ft (2.44-m) aisles and 165°F (74°C) ceiling sprinklers
G	Single-or double-row racks with 4-ft (1.22-m) aisles and 286°F (141°C) ceiling sprinklers
H	Single-or double-row racks with 4-ft (1.22-m) aisles and 165°F (74°C) ceiling sprinklers
I	Multiple-row racks with 8-ft (2.44-m) or wider aisles and 286°F (141°C) ceiling sprinklers
J	Multiple-row racks with 8-ft (2.44-m) or wider aisles and 165°F (74°C) ceiling sprinklers

FIGURE 12.3.2.1.2(a) Sprinkler System Design Curves — 20-ft (6.1-m) High Rack Storage — Class I Nonencapsulated Commodities — Conventional Pallets.



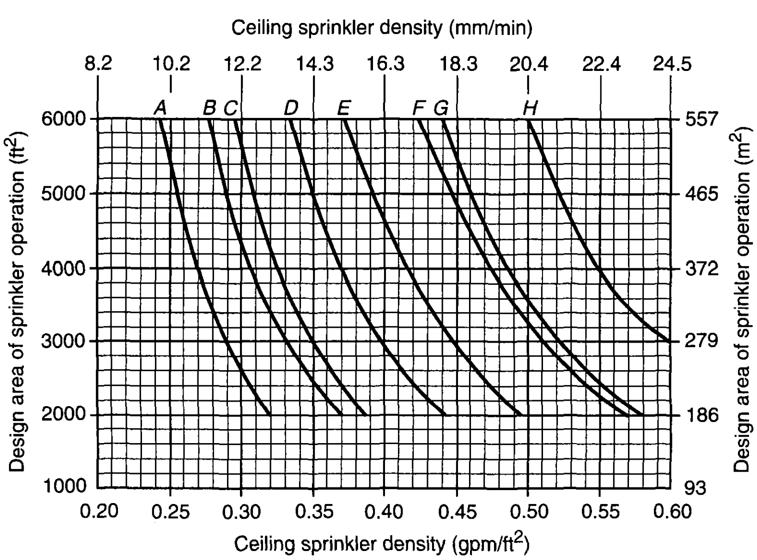
Curve	Legend
A	Single-or double-row racks with 8-ft (2.44-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
B	Single-or double-row racks with 8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
C	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
D	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
E	Single-or double-row racks with 8-ft (2.44-m) aisles and 286°F (141°C) ceiling sprinklers
F	Single-or double-row racks with 8-ft (2.44-m) aisles and 165°F (74°C) ceiling sprinklers
G	Single-or double-row racks with 4-ft (1.22-m) aisles and 286°F (141°C) ceiling sprinklers
H	Single-or double-row racks with 4-ft (1.22-m) aisles and 165°F (74°C) ceiling sprinklers
I	Multiple-row racks with 8-ft (2.44-m) or wider aisles and 286°F (141°C) ceiling sprinklers
J	Multiple-row racks with 8-ft (2.44-m) or wider aisles and 165°F (74°C) ceiling sprinklers

FIGURE 12.3.2.1.2(b) Sprinkler System Design Curves — 20-ft (6.1-m) High Rack Storage — Class II Nonencapsulated Commodities — Conventional Pallets.



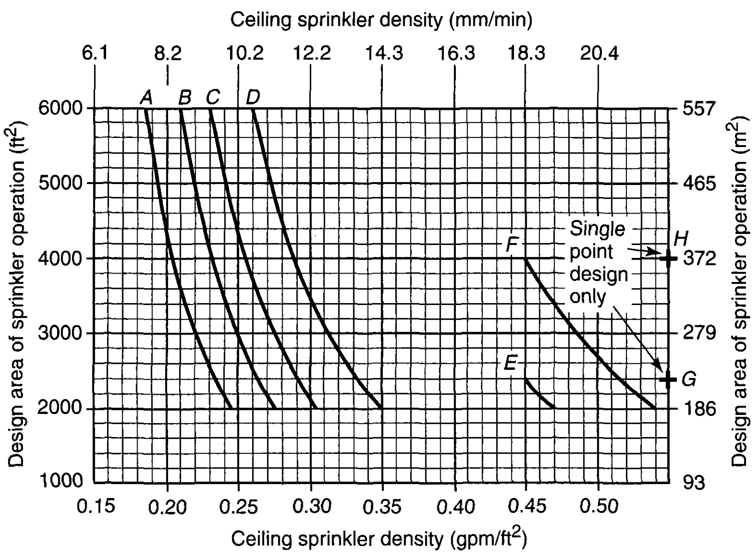
Curve	Legend
A	Single-or double-row racks with 8-ft (2.44-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
B	Single-or double-row racks with 8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
C	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
D	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
E	Single-or double-row racks with 8-ft (2.44-m) aisles and 286°F (141°C) ceiling sprinklers
F	Single-or double-row racks with 8-ft (2.44-m) aisles and 165°F (74°C) ceiling sprinklers
G	Single-or double-row racks with 4-ft (1.22-m) aisles and 286°F (141°C) ceiling sprinklers
H	Single-or double-row racks with 4-ft (1.22-m) aisles and 165°F (74°C) ceiling sprinklers
I	Multiple-row racks with 8-ft (2.44-m) or wider aisles and 286°F (141°C) ceiling sprinklers
J	Multiple-row racks with 8-ft (2.44-m) or wider aisles and 165°F (74°C) ceiling sprinklers

FIGURE 12.3.2.1.2(c) Sprinkler System Design Curves — 20-ft (6.1-m) High Rack Storage — Class III Nonencapsulated Commodities — Conventional Pallets.



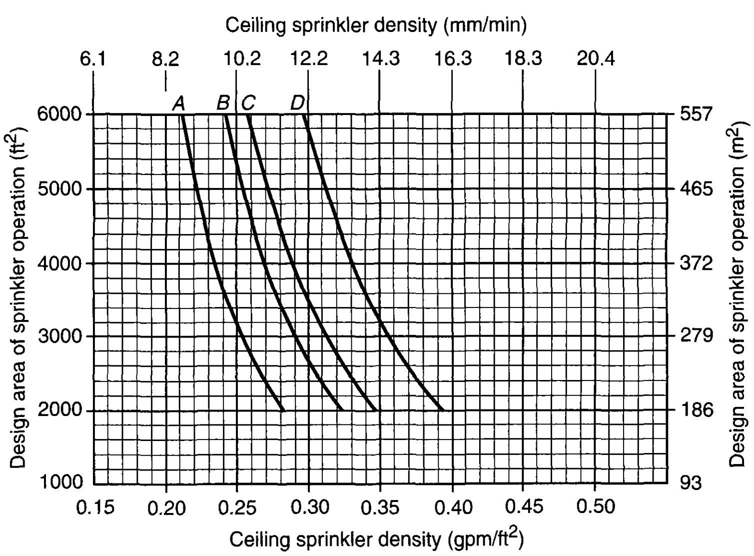
Curve	Legend
A	Single-or double-row racks with 8-ft (2.44-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
B	Single-or double-row racks with 8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
C	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
D	Single-or double-row racks with 4-ft (1.22-m) aisles or multiple-row racks with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
E	Single-or double-row racks with 8-ft (2.44-m) aisles and 286°F (141°C) ceiling sprinklers
F	Single-or double-row racks with 8-ft (2.44-m) aisles and 165°F (74°C) ceiling sprinklers
G	Single-or double-row racks with 4-ft (1.22-m) aisles and 286°F (141°C) ceiling sprinklers
H	Single-or double-row racks with 4-ft (1.22-m) aisles and 165°F (74°C) ceiling sprinklers

FIGURE 12.3.2.1.2(d) Sprinkler System Design Curves — 20-ft (6.1-m) High Rack Storage — Class IV Nonencapsulated Commodities — Conventional Pallets.



Curve	Legend
A	8-ft (2.44-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
B	8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
C	4-ft (1.22-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
D	4-ft (1.22-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
E	8-ft (2.44-m) aisles with 288°F (141°C) ceiling sprinklers
F	8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers
G	4-ft (1.22-m) aisles with 286°F (141°C) ceiling sprinklers
H	4-ft (1.22-m) aisles with 165°F (74°C) ceiling sprinklers

FIGURE 12.3.2.1.2(e) Single- or Double-Row Racks — 20-ft (6.1-m) High Rack Storage — Sprinkler System Design Curves — Class I and II Encapsulated Commodities — Conventional Pallets.



Curve	Legend
A	8-ft (2.44-m) aisles with 286°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
B	8-ft (2.44-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
C	4-ft (1.22-m) aisles with 288°F (141°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers
D	4-ft (1.22-m) aisles with 165°F (74°C) ceiling sprinklers and 165°F (74°C) in-rack sprinklers

FIGURE 12.3.2.1.2(f) Single- or Double-Row Racks — 20-ft (6.1-m) High Rack Storage — Sprinkler System Design Curves — Class III Encapsulated Commodities — Conventional Pallets.

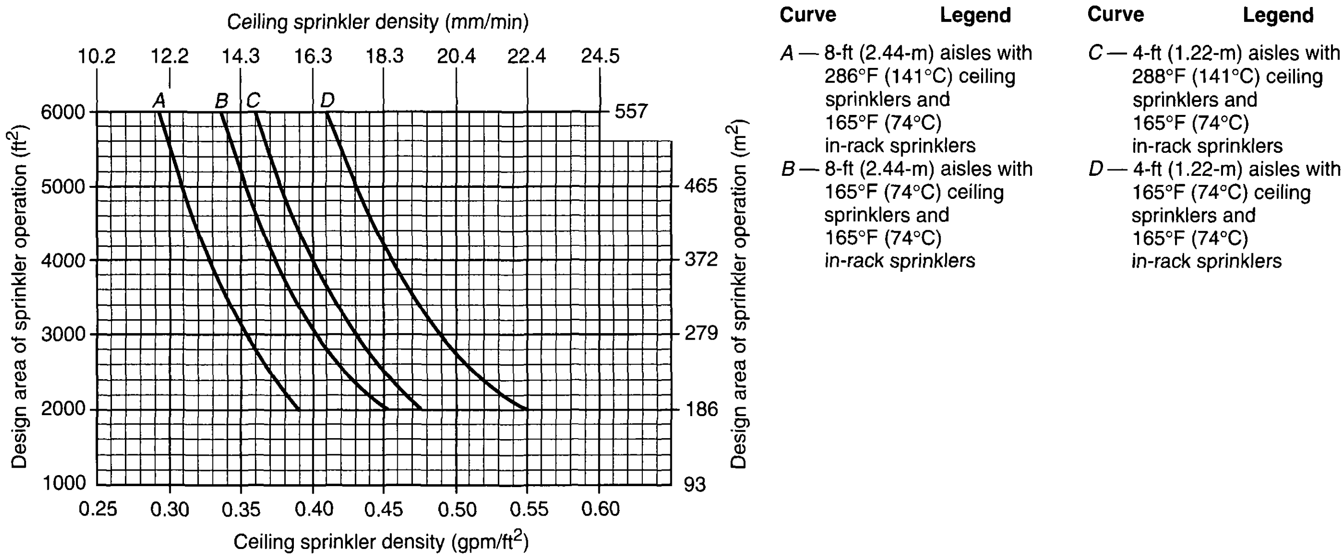


FIGURE 12.3.2.1.2(g) Single- or Double-Row Racks — 20-ft (6.1-m) High Rack Storage — Sprinkler System Design Curves — Class IV Encapsulated Commodities — Conventional Pallets.

12.3.2.1.2.1* Design densities for single- and double-row racks shall be selected to correspond to aisle width. For aisle widths between 4 ft (1.2 m) and 8 ft (2.4 m), a direct linear interpolation between densities shall be made. The density given for 8-ft (2.4-m) wide aisles shall be applied to aisles wider than 8 ft (2.4 m). The density given for 4-ft (1.2-m) wide aisles shall be applied to aisles narrower than 4 ft (1.2 m) down to 3½ ft (1.07 m). Where aisles are narrower than 3½ ft (1.07 m), racks shall be considered to be multiple-row racks. *(See Section C.15.)*

12.3.2.1.3 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m) with Aisles 8 ft (2.4 m) or Wider. For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density (gpm/ft^2) (mm/min) and area of sprinkler operation [ft^2 (m^2) of ceiling or roof] shall be selected from the density/area curves of Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(g) that are appropriate for each commodity and configuration as shown in Table 12.3.2.1.3 and shall be modified as appropriate by 12.3.2.1.5. The protection criteria shall apply to portable racks arranged in the same manner as single- or double-row racks.

12.3.2.1.4 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower than 8 ft (2.4 m). For Class I, Class II, Class III, or Class IV commodities, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density (gpm/ft^2) (mm/min) and area of sprinkler operation [ft^2 (m^2) of ceiling or roof] shall be selected from the density/area curves of Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(g) that are appropriate for each commodity and configuration as shown in Table 12.3.2.1.4 and shall be modified as appropriate by 12.3.2.1.5. The protection criteria shall apply to portable racks arranged in the same manner as single-, double-, or multiple-row racks.

12.3.2.1.5 Ceiling Sprinkler Density Adjustments.

12.3.2.1.5.1 For storage height up to and including 25 ft (7.6 m) protected with ceiling sprinklers only and for storage height up to and including 20 ft (6.1 m) protected with ceiling sprinklers and minimum required in-rack sprinklers, densities obtained from design curves shall be adjusted in accordance with Figure 12.3.2.1.5.1.

12.3.2.1.5.2 For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and minimum required in-rack sprinklers, densities obtained from design curves shall be used. Densities shall not be adjusted in accordance with Figure 12.3.2.1.5.1.

12.3.2.1.5.3 For storage height up to and including 20 ft (6.1 m) protected with ceiling sprinklers and with more than one level of in-rack sprinklers, but not in every tier, densities obtained from design curves and adjusted in accordance with Figure 12.3.2.1.5.1 shall be permitted to be reduced an additional 20 percent, as indicated in Table 12.3.2.1.5.3.

12.3.2.1.5.4 For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and with more than the minimum required level of in-rack sprinklers, but not in every tier, densities obtrained from design curves shall be permitted to be reduced 20 percent as indicated in Table 12.3.2.1.5.3. Densities shall not be adjusted in accordance with Figure 12.3.2.1.5.1 for storage height.

12.3.2.1.5.5 For storage height up to and including 20 ft (6.1 m) protected with ceiling sprinklers and in-rack sprinklers at each tier, densities obtained from design curves and adjusted in accordance with Figure 12.3.2.1.5.1 shall be permitted to be reduced an additional 40 percent, as indicated in Table 12.3.2.1.5.3.

12.3.2.1.5.6 For storage height over 20 ft (6.1 m) up to and including 25 ft (7.6 m) protected with ceiling sprinklers and in-rack sprinklers at each tier, densities obtained from design curves shall be permitted to be reduced 40 percent, as indicated in Table 12.3.2.1.5.3. Densities shall not be adjusted in accordance with Figure 12.3.2.1.5.1 for storage height.

12.3.2.1.5.7 Where clearance from ceiling to top of storage is less than 4½ ft (1.37 m), the sprinkler operating area indicated in curves E, F, G, and H in Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(e) shall be permitted to be reduced as indicated in Figure 12.3.2.1.5.7 but shall not be reduced to less than 2000 ft^2 (185.8 m^2).

Table 12.3.2.1.3 Multiple-Row Racks — Rack Depth Up to and Including 16 ft (4.9 m), Aisles 8 ft (2.4 m) or Wider, Storage Height Up to 25 ft (7.6 m)

				Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
Height	Commodity Class	Encap-sulated	Sprinklers Mandatory In-Racks	Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density	Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density
Over 12 ft (3.7 m), up to and including 15 ft (4.6 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes		12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J		Yes
	II	No		12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes		12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J		Yes
	III	No	No	12.3.2.1.2(c)			No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes		NA	NA	NA
	IV	No	No	12.3.2.1.2(d)			No	12.3.2.1.2(d)	C and D	No	No
		Yes	1 level	12.3.2.1.2(d)	A and B		1.50 × density		NA	NA	NA
Over 15 ft (4.6 m), up to and including 20 ft (6.1 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes		12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J		Yes
	II	No		12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes		12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J		Yes
	III	No	No	12.3.2.1.2(c)			No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes	NA	NA	NA	NA
	IV	No	1 level	12.3.2.1.2(d)			No				
		Yes		12.3.2.1.2(d)	A nd B		1.50 × density				
Over 20 ft (6.1 m), up to and including 25 ft (7.6 m)	I	No	No	12.3.2.1.2(a)	C and D	No	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(a)			Yes	NA	NA	NA	NA
	II	No	1 level	12.3.2.1.2(b)			No				
		Yes		12.3.2.1.2(b)			Yes				
	III	No		12.3.2.1.2(c)			No				
		Yes		12.3.2.1.2(c)			Yes				
	IV	No	2 levels	12.3.2.1.2(d)			No				
		Yes		12.3.2.1.2(d)	A and B		1.50 × density				

Table 12.3.2.1.4 Multiple-Row Racks — Rack Depth Over 16 ft (4.9 m) or Aisles Narrower than 8 ft (2.4 m), Storage Height Up to and Including 25 ft (7.6 m)

				Ceiling Sprinkler Water Demand							
				With In-Rack Sprinklers				Without In-Rack Sprinklers			
Height	Commodity Class	Encap-sulated	Sprinklers Mandatory In-Racks	Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density	Figure	Curves	Apply Figure 12.3.2.1.5.1	1.25 × Density
Over 12 ft (3.7 m), up to and including 15 ft (4.6 m)	I	No	No	12.3.2.1.2(a)	C and D	Yes	No	12.3.2.1.2(a)	I and J	Yes	No
		Yes		12.3.2.1.2(a)			Yes	12.3.2.1.2(a)	I and J		Yes
	II	No		12.3.2.1.2(b)			No	12.3.2.1.2(b)	I and J	Yes	No
		Yes		12.3.2.1.2(b)			Yes	12.3.2.1.2(b)	I and J		Yes
	III	No		12.3.2.1.2(c)			No	12.3.2.1.2(c)	I and J	Yes	No
		Yes	1 level	12.3.2.1.2(c)			Yes				
	IV	No	No	12.3.2.1.2(d)			No	12.3.2.1.2(d)	C and D	No	No
		Yes	1 level	12.3.2.1.2(d)			1.50 × density				
Over 15 ft (4.6 m), up to and including 20 ft (6.1 m)	I	No	1 level	12.3.2.1.2(a)	C and D	Yes	No	NA	NA	NA	NA
		Yes		12.3.2.1.2(a)			Yes				
	II	No		12.3.2.1.2(b)			No				
		Yes		12.3.2.1.2(b)			Yes				
	III	No		12.3.2.1.2(c)			No				
		Yes		12.3.2.1.2(c)			Yes				
	IV	No		12.3.2.1.2(d)			No				
		Yes		12.3.2.1.2(d)			1.50 × density				
Over 20 ft (6.1 m), up to and including 25 ft (7.6 m)	I	No	1 level	12.3.2.1.2(a)	C and D	No	No	NA	NA	NA	NA
		Yes		12.3.2.1.2(a)			Yes				
	II	No		12.3.2.1.2(b)			No				
		Yes		12.3.2.1.2(b)			Yes				
	III	No		12.3.2.1.2(c)			No				
		Yes		12.3.2.1.2(c)			Yes				
	IV	No	2 levels	12.3.2.1.2(d)			No				
		Yes		12.3.2.1.2(d)			1.50 × density				

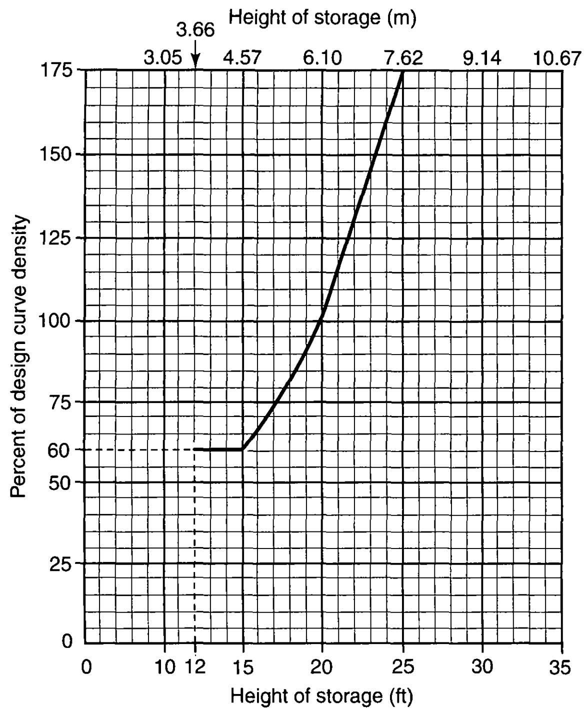


FIGURE 12.3.2.1.5.1 Ceiling Sprinkler Density vs. Storage Height.

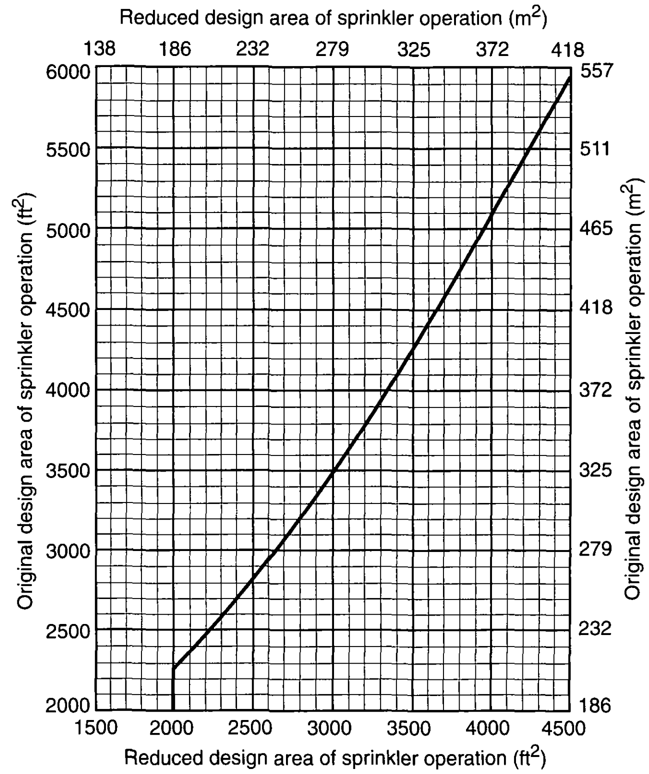


FIGURE 12.3.2.1.5.7 Adjustment of Design Area of Sprinkler Operation for Clearance from Top of Storage to Ceiling.

Table 12.3.2.1.5.3 Adjustment to Ceiling Sprinkler Density for Storage Height and In-Rack Sprinklers

Storage Height	In-Rack Sprinklers	Apply Figure 12.3.2.1.5.1 for Storage Height Adjustment	Permitted Ceiling Sprinklers Density Adjustments Where In-Rack Sprinklers are Installed
Over 12 ft (3.7 m) through 25 ft (7.6 m)	None	Yes	None
Over 12 ft (3.7 m) through 20 ft (6.1 m)	Minimum required	Yes	None
	More than minimum, but not in every tier	Yes	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier	Yes	Reduce density 40% from that of minimum in-rack sprinklers
Over 20 ft (6.1 m) through 24 ft (7.5 m)	Minimum required	No	None
	More than minimum, but not in every tier	No	Reduce density 20% from that of minimum in-rack sprinklers
	In every tier	No	Reduce density 40% from that of minimum in-rack sprinklers

12.3.2.1.5.8 Where clearance from ceiling to top of Class I or Class I encapsulated storage is 1½ ft to 3 ft (0.46 m to 0.91 m), the sprinkler operating area indicated in curve F only of Figure 12.3.2.1.2(e) shall be permitted to be reduced by 50 percent but shall not be reduced to less than 2000 ft^2 (186 m^2).

12.3.2.1.5.9 Where solid, flat-botton, combustible pallets are used with storage height up to and including 25 ft (7.6 m), the densities that are indicated in the design curves shown in Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(g), based on conventional pallets, shall be increased 20 percent for the given area. The percentage shall be applied to the density determined in accordance with Figure 12.3.2.1.5.1. The increase in density shall not apply where in-rack sprinklers are installed.

12.3.2.1.6* The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 12.3.2.1.6 to the water supply for sprinklers determined in 12.3.2.1. This supply shall be available for the minimum duration specified in Table 12.3.2.1.6. *(See Section C.8.)*

12.3.2.1.6.1 An allowance for inside and outside hose shall not be required where tanks supply sprinklers only.

12.3.2.1.6.2 Where pumps taking suction from a private fire service main supply sprinklers only, the pump need not be sized to accommodate inside and outside hose. Such hose allowance shall be considered in evaluating the available water supplies.

12.3.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.2.1 Protection of single-, double-, and multiple-row rack storage without solid shelves for Classes I through IV commodities shall be in accordance with Table 12.3.2.2.1(a) or Table 12.3.2.2.1(b).

12.3.2.2.2 Where in-rack sprinklers are required by Table 12.3.2.2.1(a) and Table 12.3.2.2.1(b), in-rack sprinkler spacing, design pressure, and hydraulic calculation criteria shall be in accordance with the requirements of 12.3.2.4 as applicable for the commodity.

12.3.2.2.3 Protection shall be provided as specified in Table 12.3.2.2.1(a) and Table 12.3.2.2.1(b) or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

12.3.2.2.3.1 For design purposes, 95 psi (6.6 bar) shall be the maximum discharge pressure at the hydraulically most remote sprinkler.

12.3.2.2.3.2 Open Wood Joist Construction.

(A) Where large drop K–11.2 sprinklers are installed under open wood joist construction, their minimum operating pressure shall be 50 psi (3.4 bar).

(B) Where each joist channel of open, wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 12.3.2.2.1(a) shall be permitted to be used.

12.3.2.2.3.3 The design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area protected by the number of sprinklers to be included in the design area. Any fractional sprinkler shall be included in the design area.

12.3.2.2.3.4 Hose stream demand and water supply duration requirements shall be in accordance with Table 12.3.2.2.1(a) and Table 12.3.2.2.1(b).

12.3.2.2.3.5 Preaction Systems.

(A) For the purpose of using Table 12.3.2.2.1(a) and Table 12.3.2.2.1(b), preaction systems shall be classified as dry pipe systems.

(B) Where it can be demonstrated that the detection system activating the preaction system will cause water to be at the sprinklers when they operate, preaction systems shall be permitted to be treated as wet pipe systems.

12.3.2.2.3.6 The nominal diameter of branch line pipes (including riser nipples) shall meet the following:

(1) Pipe diameter shall not be not less than 1¼ in. (33 mm) nor greater than 2 in. (51 mm).
(2) Starter pieces shall be permitted to be 2½ in. (64 mm).
(3) Where branch lines are larger than 2 in. (51 mm), the sprinkler shall be supplied by a riser nipple to elevate the sprinkler 13 in. (330 mm) for 2½ in. (64-mm) pipe and 15 in. (380 mm) for 3-in. (76-mm) pipe. These dimensions are measured from the centerline of the pipe to the deflector. In lieu of this, sprinklers shall be permitted to be offset horizontally a minimum of 12 in. (305 mm).

12.3.2.2.3.7 Building steel shall not require special protection where Table 12.3.2.2.1(a) and Table 12.3.2.2.1(b) is applied as appropriate for the storage configuration.

12.3.2.3* Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.3.1 Protection of single-, double-, and multiple-row rack storage of Classes I through IV shall be in accordance with Table 12.3.2.3.1.

Table 12.3.2.1.6 Hose Stream Demand and Water Supply Duration Requirements for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Class I, II, and III	Over 12	Over 3.7	0, 50, or 100	0, 190, 380	500	1900	90
Class IV	Over 12	Over 3.7	0, 50, or 100	0, 190, 380	500	1900	120

Table 12.3.2.2.1(a) Large Drop Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Class	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/Roof Height		Type of System	Number of Design Sprinklers/Minimum Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m		/psi	/bar	gpm	L/min	
I, II	11.2	25	7.6	30	9.1	Wet	20/25	20/1.7	500	1900	1½
						Dry	30/25	30/1.7	500	1900	1½
I, II, III	11.2	20	6.1	30	9.1	Wet	15/25	15/1.7	500	1900	1½
						Dry	25/25	25/1.7	N/A	N/A	1½
I, II, III	11.2	25	7.6	35	10.7	Wet	15/25 + 1 level of in-rack	15/1.7 + 1 level of in-rack	500	1900	1½
						Dry	25/25 + 1 level of in-rack	25/1.7 + 1 level of in-rack	500	1900	1½
IV	11.2	20	6.1	25	7.6	Wet	15/50	15/3.4	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
IV	11.2	20	6.1	30	9.1	Wet	20/50	20/3.4	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
IV	11.2	20	6.1	30	9.1	Wet	15/75	15/5.2	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
IV	11.2	25	7.6	30	9.1	Wet	15/50 + 1 level of in-rack	15/3.4 + 1 level of in-rack	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
IV	11.2	25	7.6	35	10.7	Wet	20/50 + 1 level of in-rack	20/3.4 + 1 level of in-rack	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
IV	11.2	25	7.6	35	10.7	Wet	15/75 + 1 level of in-rack	15/5.2 + 1 level of in-rack	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A

Table 12.3.2.2.1(b) Specific Application Control Mode (16.8 K-factor) Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
	ft	m	ft	m		10 psi 0.7 bar	22 psi 1.5 bar	gpm	L/min	
I or II	25	7.6	30	9.1	Wet	15	—	500	1900	1½
III or IV	25	7.6	30	9.1	Wet	—	15	500	1900	2

Table 12.3.2.3.1 ESFR Protection of Rack Storage without Solid Shelves of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Storage Arrangement	Commodity	Maximum Storage Height ft	Maximum Storage Height m	Maximum Ceiling/ Roof Height ft	Maximum Ceiling/ Roof Height m	Nominal K-Factor	Orientation	Minimum Operating Pressure psi	Minimum Operating Pressure bar	In-Rack Sprinkler Requirements	Hose Stream Demand gpm	Hose Stream Demand L/min	Water Supply Duration (hours)
Single-row, double-row, and multiple-row rack (no open-top containers)	Class I, II, III, or IV, encapsulated or unencapsulated	20	6.1	25	7.6	11.2	Upright	50	3.4	No	250	946	1
						14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
						25.2	Pendent	15	1.0	No			
				30	9.1	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
						25.2	Pendent	15	1.0	No			
				35	10.7	14.0	Upright or pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	20	1.4	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	64	4.4	Yes			
						25.2	Pendent	40	2.8	No			
		25	7.6	30	9.1	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
						25.2	Pendent	15	1.0	No			
				32	9.8	14.0	Upright or pendent	60	4.1	No			
						16.8	Pendent	42	2.9	No			
				35	10.7	14.0	Upright or pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	20	1.4	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	64	4.4	Yes			
						25.2	Pendent	40	2.8	No			

12.3.2.3.1.1 ESFR protection as defined shall not apply to the following:

(1) Rack storage involving solid shelves
(2) Rack storage involving combustible, open-top cartons or containers

12.3.2.3.2 Detection systems, concentrate pumps, generators, and other system components that are essential to the operation of the system shall have an approved standby power source.

12.3.2.3.3 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 12.3.2.3.1 for type of storage, commodity, storage height, and building height involved.

12.3.2.3.4 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines. The design shall include a minimum of 960 ft^2 (89 m^2).

12.3.2.3.5 Where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers for one of the levels shall be included with those of the other level in the hydraulic calculations.

12.3.2.4 In-Rack Sprinklers for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.4.1 In-Rack Sprinkler Location for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.4.1.1 In single- or double-row racks without solid shelves, in-rack sprinklers shall be installed in accordance with Table 12.3.2.1.2.

12.3.2.4.1.2 In multiple-row racks no deeper than 16 ft (4.9 m) with aisles 8 ft (2.4 m) or wider, in-rack sprinklers shall be installed in accordance with Table 12.3.2.1.3.

12.3.2.4.1.3 In multiple-row racks deeper than 16 ft (4.9 m) or with aisles less than 8 ft (2.4 m) wide, in-rack sprinklers shall be installed in accordance with Table 12.3.2.1.4.

12.3.2.4.1.4 In-rack sprinklers at one level only for storage up to and including 25 ft (7.6 m) high shall be located at the first tier level at or above one-half of the storage height.

12.3.2.4.1.5 In-rack sprinklers at two levels only for storage up to and including 25 ft (7.6 m) high shall be located at the first tier level at or above one-third and two-thirds of the storage height.

12.3.2.4.2 In-Rack Sprinkler Spacing for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.4.2.1* Maximum horizontal spacing of in-rack sprinklers in single- or double-row racks with nonencapsulated storage up to and including 25 ft (7.6 m) in height shall be in accordance with Table 12.3.2.4.2.1. For encapsulated storage, maximum horizontal spacing shall be 8 ft (2.44 m).

12.3.2.4.2.2* Maximum horizontal spacing of in-rack sprinklers on branch lines, in multiple-row racks with encapsulated or nonencapsulated storage up to and including 25 ft (7.6 m) in height, shall not exceed 12 ft (3.7 m) for Class I, II, or III commodities and 8 ft (2.4 m) for Class IV commodities, with area limitations of 100 ft^2 (9.3 m^2) per sprinkler for Class I, II, or III commodities and 80 ft^2 (7.4 m^2) per sprinkler for Class IV commodities. The rack plan view shall be considered in determining the area covered by each sprinkler. The aisles shall not be included in area calculations.

Table 12.3.2.4.2.1 In-Rack Sprinkler Spacing for Class I, II, III, and IV Commodities Stored up to 25 ft (7.6 m) in Height

Aisle Widths		Commodity Class					
		I and II		III		IV	
ft	m	ft	m	ft	m	ft	m
8	2.4	12	3.7	12	3.7	8	2.4
4	1.2	12	3.7	8	2.4	8	2.4

12.3.2.4.2.3* The elevation of in-rack sprinkler deflectors with respect to storage shall not be a consideration in single- or double-row rack storage up to and including 20 ft (6.1 m) high. *(See Section C.16.)*

12.3.2.4.2.4* In single- or double-row racks without solid shelves with storage over 20 ft (6.1 m) high, or in multiple-row racks, or in single- or double-row racks with solid shelves and storage height up to and including 25 ft (7.6 m), a minimum of 6-in. (152.4-mm) vertical clear space shall be maintained between the in-rack sprinkler deflectors and the top of a tier of storage. Sprinkler discharge shall not be obstructed by horizontal rack members.

12.3.2.4.2.5 For multiple-row racks, a minimum of 6 in. (152.4 mm) shall be maintained between the in-rack sprinkler deflector and the top of a tier of storage.

12.3.2.4.2.6 Sprinklers installed in racks shall be spaced without regard to rack uprights. *(See Section C.17.)*

12.3.2.4.3 In-Rack Sprinkler Water Demand for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height. *(See Section C.18.)*

12.3.2.4.3.1 The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote sprinklers as follows:

(1) Six sprinklers where only one level is installed in racks with Class I, Class II, or Class III commodities
(2) Eight sprinklers where only one level is installed in racks with Class IV commodities
(3) Ten sprinklers (five on each two top levels) where more than one level is installed in racks with Class I, Class II, or Class III commodities
(4) Fourteen sprinklers (seven on each two top levels) where more than one level is installed in racks with Class IV commodities

12.3.2.4.3.2 Where a storage rack, due to its length, requires less than the number of in-rack sprinklers specified in 12.3.2.4.3.1(1) through 12.3.2.4.3.1(4), only those in-rack sprinklers in a single rack need to be included in the calculation.

12.3.2.4.4 In-Rack Sprinkler Discharge Pressure for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height. Sprinklers in racks shall discharge at not less than 15 psi (1 bar) for all classes of commodities. *(See Section C.19.)*

12.3.2.5 Special Design for Rack Storage of Class I through Class IV Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.2.5.1 Slatted Shelves.

12.3.2.5.1.1* Slatted shelves shall be considered equivalent to solid shelves where the requirements of 12.3.2.5.1 are not met. *(See Section C.20.)*

12.3.2.5.1.2 A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft^2 (24.5 mm/min) density over a minimum area of 2000 ft^2 (186 m^2) or K-14.0 ESFR sprinklers operating at a minimum of 50 psi (3.5 bar), K-16.8 sprinklers operating at a minimum of 32 psi (1.7 bar), or K-25.2 ESFR sprinklers operating at a minimum of 15 psi shall be permitted to protect single-row and double-row slatted-shelf racks where all of the following conditions are met:

(1) Sprinklers shall be K-11.2, K-14.0, or K-16.8 orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies or shall be K-14.0 , K-16.8, or K-25.2 ESFR.
(2) The protected commodities shall be limited to Class I-IV, Group B plastics, Group C plastics, cartoned (expanded and unexpanded) Group A plastics, and exposed (unexpanded) Group A plastics.
(3) Shelves shall be slatted using a minimum nominal 2-in. (51-mm) thick by maximum nominal 6-in. (152-mm) wide slat held in place by spacers that maintain a minimum 2-in. (51-mm) opening between each slat.
(4) Where K-11.2, K-14.0, or K-16.8 orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Wire mesh (greater than 50 percent opening) shall be permitted for shelf levels above 12 ft (3.7 m).
(5) Transverse flue spaces at least 3 in. (76 mm) wide shall be provided at least every 10 ft (3.1 m) horizontally.
(6) Longitudinal flue spaces at least 6 in. (152 mm) wide shall be provided for double-row racks. Longitudinal flue spaces shall not be required where ESFR sprinklers are used.
(7) The aisle widths shall be at least 7½ ft (2.3 m).
(8) The maximum roof height shall be 27 ft (8.2 m) or 30 ft where ESFR sprinklers are used.
(9) The maximum storage height shall be 20 ft (6.1 m).
(10) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2-in. (51-mm) spaces between slats, nor shall they be placed on the wire mesh shelves.

12.3.2.5.2 High-Expansion Foam Ceiling Sprinkler Density. Where high-expansion foam systems are used in combination with ceiling sprinklers, the minimum ceiling sprinkler design density shall be 0.2 gpm/ft^2 (8.2 mm/min) for Class I, Class II, or Class III commodities or 0.25 gpm/ft^2 (10.2 mm/min) for Class IV commodities for the most hydraulically remote 2000-ft^2 (186-m^2) operating area.

12.3.2.5.2.1 Where high-expansion foam systems are used in combination with ceiling sprinklers, the maximum submergence time shall be 7 minutes for Class I, Class II, or Class III commodities and 5 minutes for Class IV commodities.

12.3.2.5.2.2* Where high-expansion foam systems are used without sprinklers, the maximum submergence time shall be 5 minutes for Class I, Class II, or Class III commodities and 4 minutes for Class IV commodities.

12.3.3 Protection Criteria for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.3.1 Control Mode Density-Area Sprinkler Protection Criteria for Single-, Double-, and Multiple-Row Racks for Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height, with Clearances Up to and Including 10 ft (3.1 m).

12.3.3.1.1 Plastic commodities shall be protected in accordance with Figure 12.3.3.1.1. This decision tree also shall be used to determine protection for commodities that are not entirely Group A plastics but contain such quantities and arrangements of Group A plastics that they are deemed more hazardous than Class IV commodities. The design criteria of 12.3.3.1 for single- and double-row rack storage of plastic commodities shall be applicable where aisles are 3.5 ft or greater in width. Storage with aisles less than 3.5 ft shall be protected as multiple-row rack storage. *(See Section C.21.)*

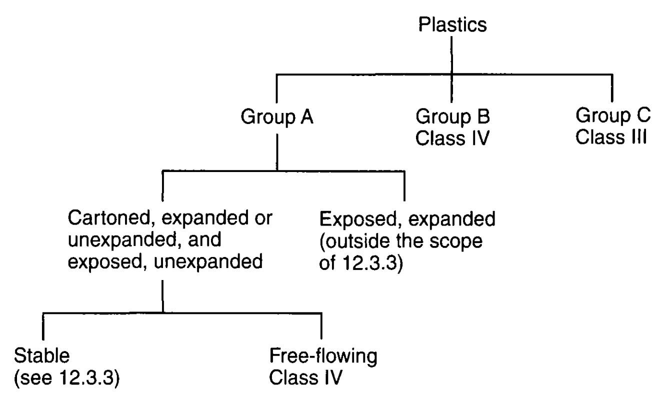


FIGURE 12.3.3.1.1 Decision Tree.

12.3.3.1.2* For the storage of Group A plastics stored 5 ft (1.5 m) or less in height, the sprinkler design criteria for miscellaneous storage specified in 12.1.10 shall be used.

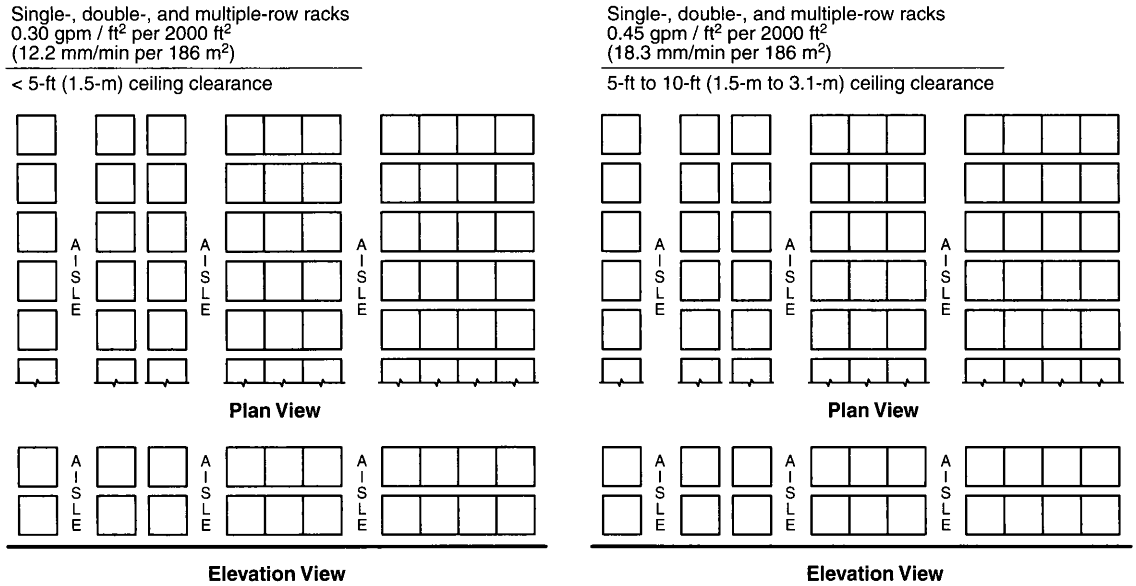
12.3.3.1.3 Group B plastics and free-flowing Group A plastics shall be protected the same as Class IV commodities.

12.3.3.1.4 Group C plastics shall be protected the same as Class III commodities.

12.3.3.1.5 Ceiling Sprinkler Water Demand. For Group A plastic commodities in cartons, encapsulated or nonencapsulated in single-, double-, and multiple-row racks, ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)] shall be selected from Figure 12.3.3.1.5(a) through Figure 12.3.3.1.5(f). Linear interpolation of design densities and areas of application shall be permitted between storage heights with the same clearances. No interpolation between clearances shall be permitted. *(See Section C.22.)*

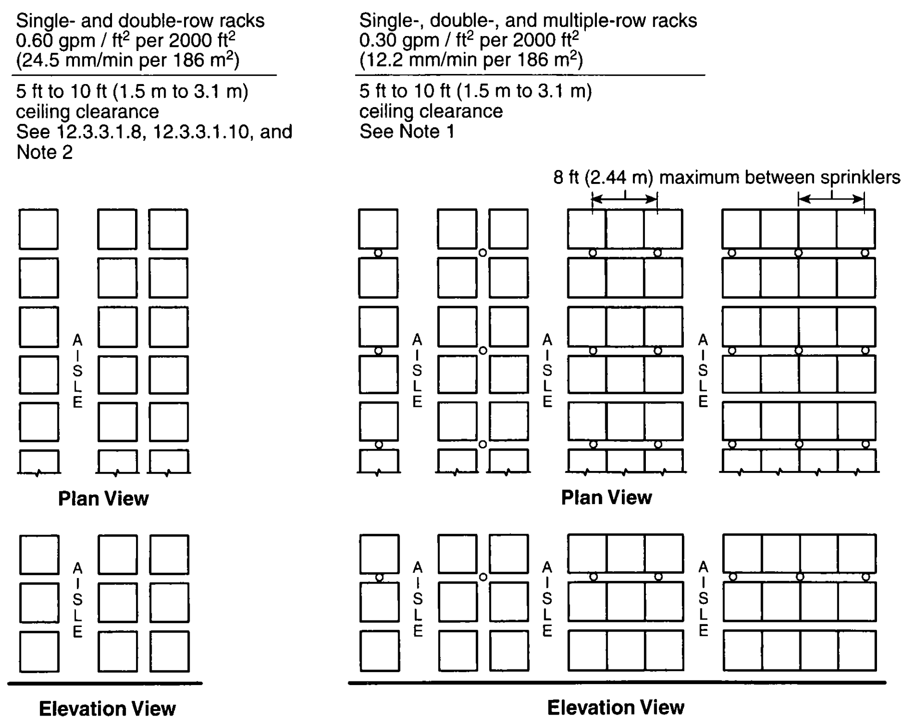
12.3.3.1.6 Single-, Double-, and Multiple-Row Racks Up to 10-ft (3.1-m) Storage with Up to 10-ft (3.1-m) Clearance. The protection strategies utilizing only ceiling sprinklers, as shown in Figure 12.3.3.1.5(a), shall be acceptable for single-, double-, and multiple-row rack storage.

12.3.3.1.7 Single- and Double-Row Rack Storage Greater than 10 ft (3.1 m) Up to 15 ft (4.6 m) with Less than 5-ft (1.25-m) Clearance. The protection strategy utilizing only ceiling sprinklers, as shown in Figure 12.3.3.1.5(b), shall be acceptable only for single- and double-row rack storage.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

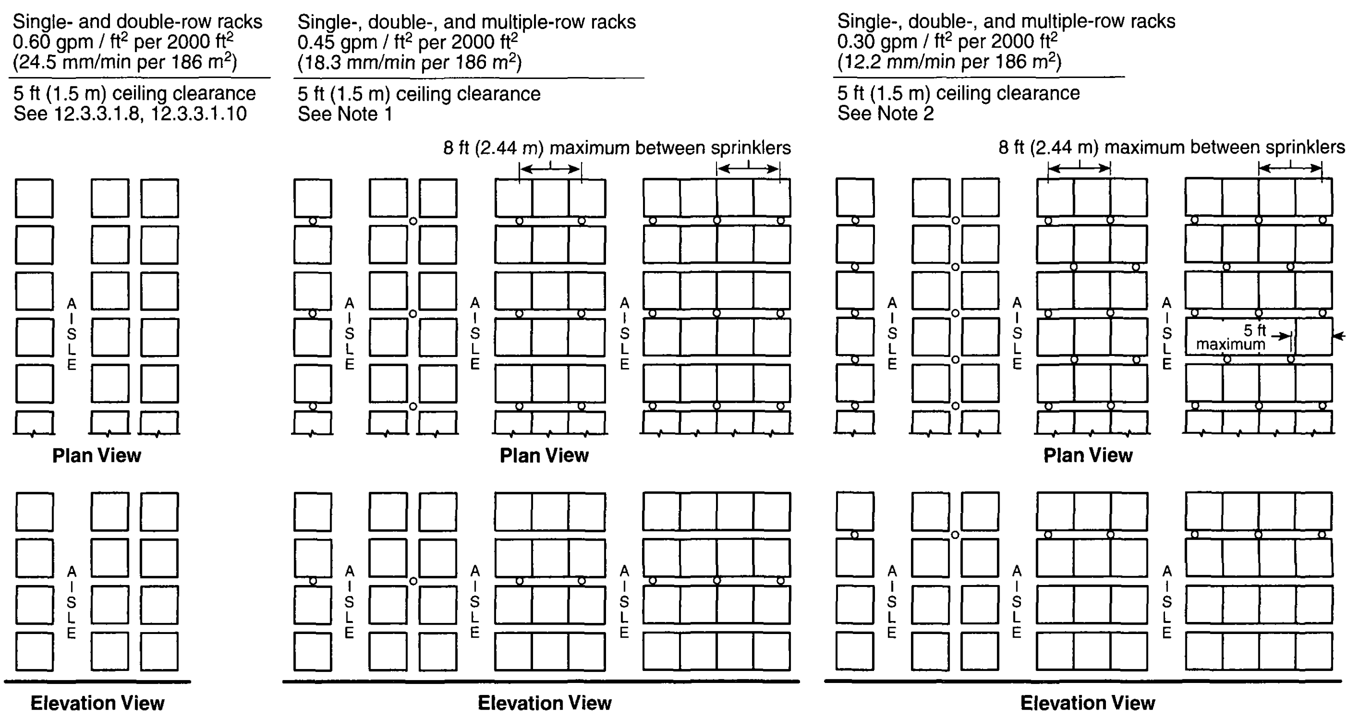
FIGURE 12.3.3.1.5(a) 5-ft to 10-ft (1.5-m to 3-m) Storage.



Notes:

1. Single level of in-rack sprinklers [½ in. or $^{17}/_{32}$ in. (12.7 mm or 13.5 mm) operating at 15 psi (1.03 bar) minimum] installed as indicated in the transverse flue spaces.
2. Where sprinklers listed for storage use are installed at the ceiling only and the ceiling height in the protected area does not exceed 22 ft (6.7 m) and a minimum clearance of 7 ft (2.13 m), the ceiling sprinkler discharge criteria shall be permitted to be reduced to 0.45 gpm/ft² per 2000 ft² (18.3 mm/min per 186 m²).
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

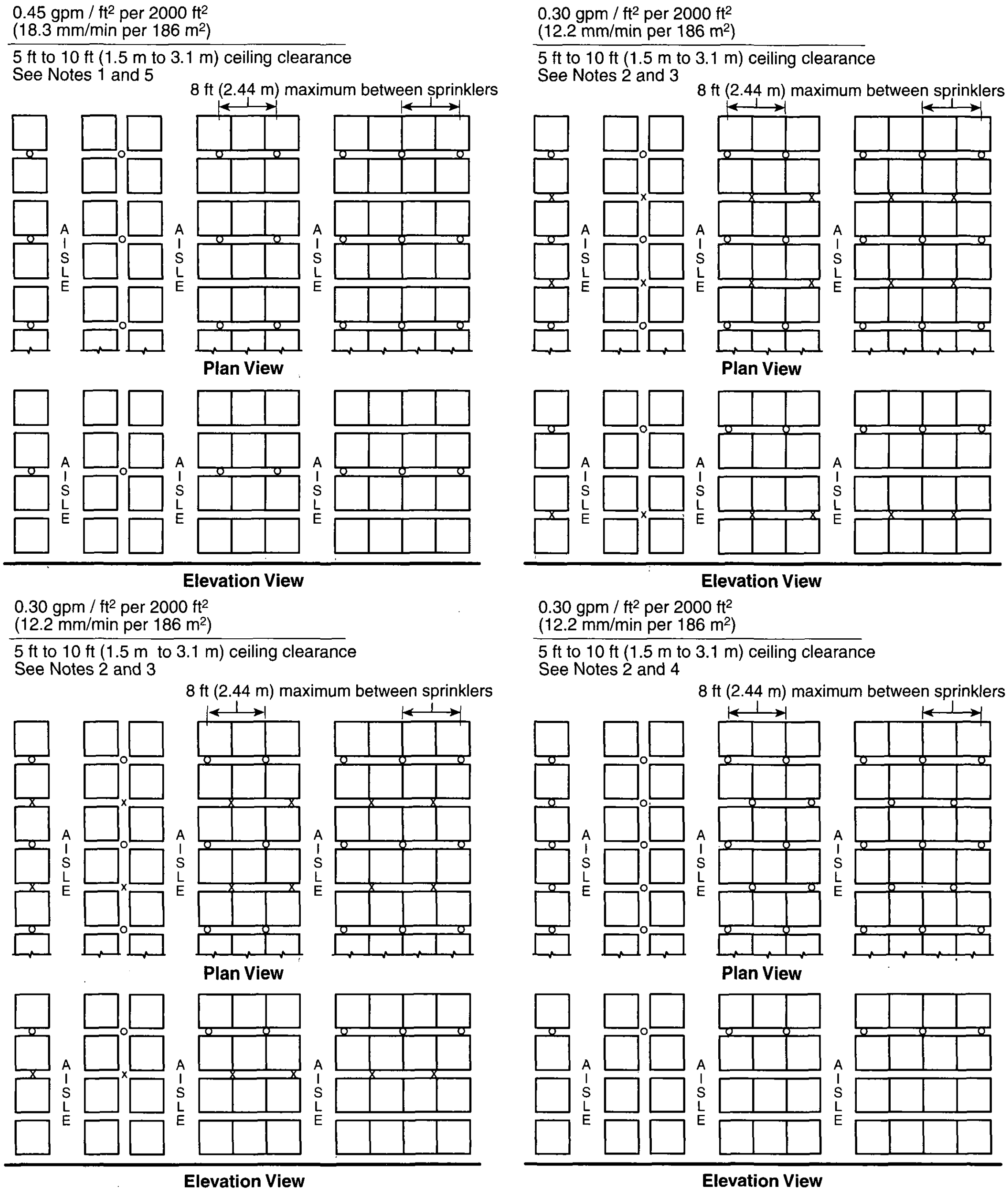
FIGURE 12.3.3.1.5(b) 15-ft (4.6-m) Storage; Up to 10-ft (1.5-m to 3.1-m) Ceiling Clearance.



Notes:

1. Single level of in-rack sprinklers [½ in. or 17⁄32 in. (12.7 mm or 13.5 mm) operating at 15 psi (1.03 bar) minimum] installed as indicated in the transverse flue spaces.
2. Single level of in-rack sprinklers [17⁄32 in. (13.5 mm) operating at 15 psi (1.03 bar) minimum or ½ in. (12.7 mm) operating at 30 psi (2.07 bar) minimum] installed on 4 ft to 5 ft (1.25 m to 1.56 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

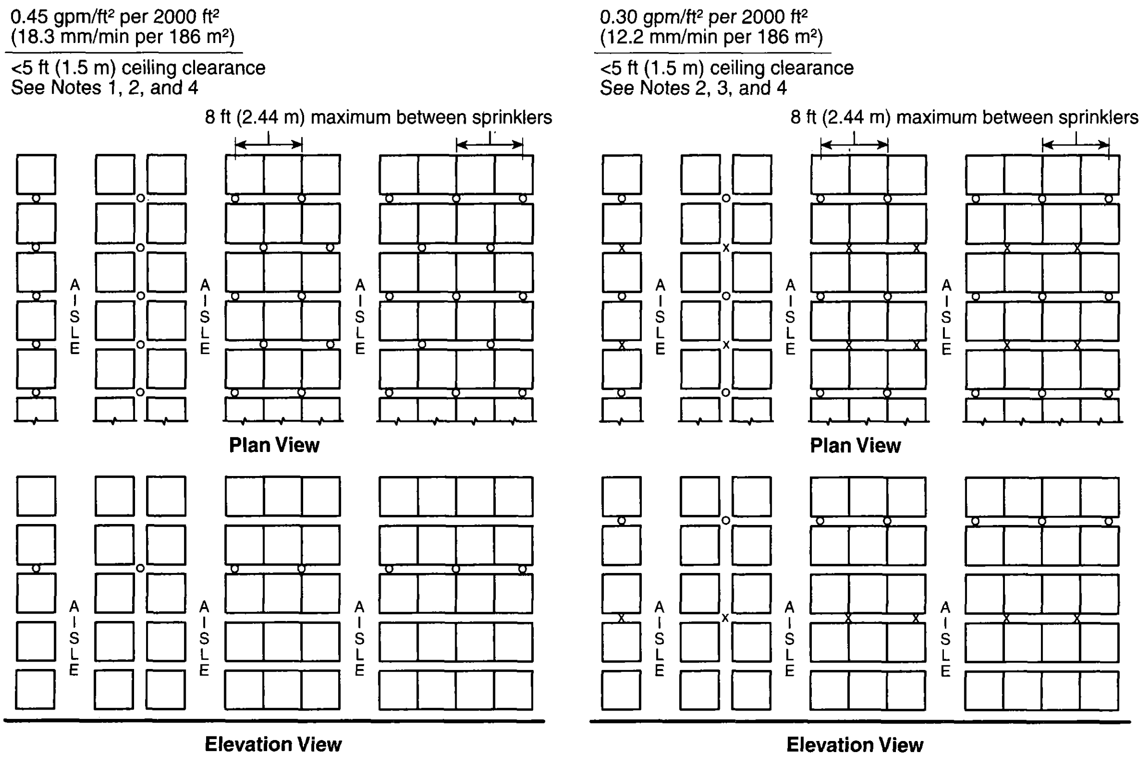
FIGURE 12.3.3.1.5(c) 20-ft (6.1-m) Storage; <5-ft (1.5-m) Ceiling Clearance.



Notes:

1. Single level of in-rack sprinklers [½ in. or 17⁄32 in. (12.7 mm or 13.5 mm) operating at 15 psi (1.03 bar) minimum] installed as indicated in the transverse flue spaces.
2. Ceiling-only protection shall not be permitted for this storage configuration.
3. Two levels of in-rack sprinklers [½ in. or 17⁄32 in. (12.7 mm or 13.5 mm) operating at 15 psi (1.03 bar) minimum] installed as indicated and staggered in the transverse flue space.
4. Single level of in-rack sprinklers [17⁄32 in. (13.5 mm) operating at 15 psi (1.03 bar) minimum or ½ in. (12.7 mm) operating at 30 psi (2.07 bar) minimum] installed on 4 ft to 5 ft (1.25 m to 1.56 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
5. Where K-11.2, K-14, K-16.8 spray sprinklers listed for storage use are installed at the ceiling, the in-rack sprinklers shall not be required, provided the ceiling sprinkler discharge criteria is increased to 0.6 gpm/ft² [24 (L/min)/m²] over 2000 ft² (186 m²) and the ceiling height in the protected area does not exceed 27 ft (8.2 m).
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.3.1.5(d) 20-ft (6.1-m) Storage; 5-ft to 10-ft (1.5-m to 3.1-m) Ceiling Clearance.



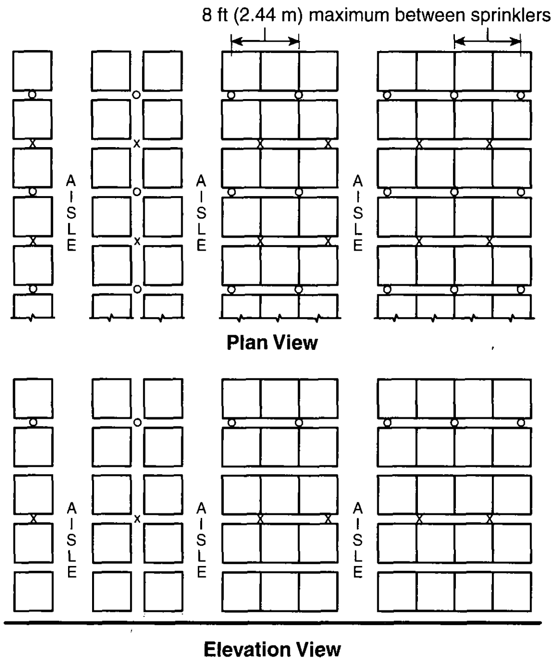
Notes:

1. Single level of in-rack sprinklers [$\tfrac{17}{32}$ in. (13.5 mm) operating at 15 psi (1.03 bar) minimum or $\tfrac{1}{2}$ in. (12.7 mm) operating at 30 psi (2.07 bar) minimum] installed on 4 ft to 5 ft (1.25 m to 1.56 m) spacings located, as indicated, in the longitudinal flue space at the intersection of every transverse flue space.
2. Ceiling-only protection shall not be permitted for this storage configuration.
3. Two levels of in-rack sprinklers [$\tfrac{1}{2}$ in. or $\tfrac{17}{32}$ in. (12.7 mm or 13.5 mm) operating at 15 psi (1.03 bar) minimum] installed as indicated and staggered in the transverse flue space.
4. Where K-16.8 spray sprinklers listed for storage use are installed at the ceiling, the in-rack sprinklers shall not be required, provided the ceiling sprinklers criteria is increased to 0.8 gpm/ft^2 over 2000 ft^2 (32.6 mm/min over 186 m^2) for wet systems and 4500 ft^2 (419 m^2) for dry systems and the ceiling height in the protected area does not exceed 30 ft (9.1 m).
5. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.3.1.5(e) 25-ft (7.6-m) Storage; <5-ft (1.5-m) Ceiling Clearance. *(See Note 2.)*

0.30 gpm/ft² per 2000 ft²
(12.2 mm/min per 186 m²)

5 ft to 10 ft (1.5 m to 3.1 m) ceiling clearance
See Notes 1, 2, and 3



Notes:

1. Two levels of in-rack sprinklers [½ in. or 17/32 in. (12.7 mm or 13.5 mm) operating at 15 psi (1.03 bar) minimum] installed on 8 ft to 10 ft (2.5 m to 3.12 m) spacings located as indicated and staggered in the transverse flue space.
2. Ceiling-only protection shall not be permitted for this storage configuration.
3. Where K-16.8 spray sprinklers listed for storage use are installed at the ceiling, the in-rack sprinklers shall not be required, provided the ceiling sprinklers criteria is increased to 0.8 gpm/ft² over 2000 ft² (32.6 mm/min over 186 m²) for wet systems and 4500 ft² (419 m²) for dry systems and the ceiling height in the protected area does not exceed 30 ft (9.1 m).
4. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.3.1.5(f) 25-ft (7.6-m) Storage; 5-ft to 10-ft (1.5-m to 3.1-m) Ceiling Clearance. *(See Note 2.)*

12.3.3.1.8 Single- and Double-Row Rack Storage Greater than 10 ft (3.1 m) Up to 15 ft (4.6 m) with Clearance from 5 ft to 10 ft (1.5 m to 3.1 m), and Single- and Double-Row Rack Storage Up to 20 ft (6.1 m) with Less than 5-ft (1.5-m) Clearance. The protection strategies utilizing only ceiling sprinklers, as shown in Figure 12.3.3.1.5(c) and Figure 12.3.3.1.5(d), shall be acceptable only for single- and double-row rack storage.

12.3.3.1.9 Multiple-Row Racks — 15-ft (4.6-m) Storage with Less than 5-ft (1.5-m) Clearance. Where using the protection strategy utilizing only ceiling sprinklers, as shown in Figure 12.3.3.1.5(b), for multiple-row rack storage, the density to be used shall be 0.6 gpm/ft² (24.5 mm/min) over 2000 ft² (186 m²). The combination of ceiling and in-rack sprinklers specified in Figure 12.3.3.1.5(b) shall be permitted as an alternative.

12.3.3.1.10 Multiple-Row Racks — 15-ft (4.6-m) Storage with 10-ft (3.1-m) Clearance, and 20-ft (6.1-m) Storage with Less than 5-ft (1.5-m) Clearance. The protection strategies utilizing only ceiling sprinklers, as shown in Figure 12.3.3.1.5(c) and Figure 12.3.3.1.5(d), shall not be permitted for multiple-row rack storage. Only the specified combinations of ceiling and in-rack sprinklers shall be used.

12.3.3.1.11* The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 12.3.3.1.11 to the water supply for sprinklers determined in 12.3.3.1. This supply shall be available for the minimum duration specified in Table 12.3.3.1.11. *(See Section C.8.)*

12.3.3.1.11.1 An allowance for inside and outside hose shall not be required where tanks supply sprinklers only.

12.3.3.1.11.2 Where pumps taking suction from a private fire service main supply sprinklers only, the pump need not be sized to accommodate inside and outside hose. Such hose allowance shall be considered in evaluating the available water supplies.

12.3.3.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.3.2.1 Protection of single-, double-, and multiple-row rack storage without solid shelves for unexpanded plastic commodities shall be in accordance with Table 12.3.3.2.1(a) and Table 12.3.3.2.1(b).

12.3.3.2.2 Where in-rack sprinklers are required by Table 12.3.3.2.1(a) and Table 12.3.3.2.1(b), in-rack sprinkler spacing, design pressure, and hydraulic calculation criteria shall be in accordance with the requirements of 12.3.2.4 as applicable for the commodity.

12.3.3.2.3 Protection shall be provided as specified in Table 12.3.3.2.1(a) and Table 12.3.3.2.1(b) or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

Table 12.3.3.1.11 Hose Stream Demand and Water Supply Duration Requirements for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Plastic	>5 up to 20	>1.5 up to 6.1	0, 50, or 100	0, 190, or 380	500	1900	120
	>20 up to 25	>6.1 up to 7.6	0, 50, or 100	0, 190, or 380	500	1900	150

Table 12.3.3.2.1(a) Large Drop Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Class	Nominal K-Factor	Maximum Storage Height		Maximum Ceiling/ Roof Height		Type of System	Number of Design Sprinklers/Minimum Pressure		Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m		/psi	/bar	gpm	L/min	
Cartoned or exposed unexpanded plastics	11.2	20	6.1	25	7.6	Wet	15/50	15/3.4	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
Cartoned or exposed unexpanded plastics	11.2	20	6.1	30	9.1	Wet	30/50	30/3.4	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
						Wet	20/75	20/5.2	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
Cartoned or exposed unexpanded plastics	11.2	25	7.6	30	9.1	Wet	15/50 + 1 level of in-rack	15/3.4 + 1 level of in-rack	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
Cartoned or exposed unexpanded plastics	11.2	25	7.6	35	10.7	Wet	30/50 + 1 level of in-rack	30/3.4 + 1 level of in-rack	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A
						Wet	20/75 + 1 level of in-rack	20/5.2 + 1 level of in-rack	500	1900	2
						Dry	N/A	N/A	N/A	N/A	N/A

Table 12.3.3.2.1(b) Specific Application Control Mode (16.8 K-factor) Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Commodity Class	Maximum Storage Height		Maximum Building Height		Type of System	Number of Design Sprinklers by Minimum Operating Pressure		Hose Stream Demand		Water Supply Duration (hours)
	ft	m	ft	m		10 psi (0.7 bar)	22 psi (1.5 bar)	gpm	L/min	
Cartoned or exposed unexpanded plastics	25	7.6	30	9.1	Wet	—	15	500	1900	2

12.3.3.2.3.1 For design purposes, 95 psi (6.6 bar) shall be the maximum discharge pressure at the hydraulically most remote sprinkler.

12.3.3.2.3.2 Open Wood Joist Construction.

(A) Where large drop K-11.2 sprinklers are installed under open wood joist construction, their minimum operating pressure shall be 50 psi (3.4 bar).

(B) Where each joist channel of open, wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 12.3.3.2.1(a) shall be permitted to be used.

12.3.3.2.3.3 The design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area protected by the number of sprinklers to be included in the design area. Any fractional sprinkler shall be included in the design area.

12.3.3.2.3.4 Hose stream demand and water supply duration requirements shall be in accordance with those for extra hazard occupancies in Table 12.3.3.2.1(a) and Table 12.3.3.2.1(b).

12.3.3.2.3.5 Preaction Systems.

(A) For the purpose of using Table 12.3.3.2.1(a) and Table 12.3.3.2.1(b), preaction systems shall be classified as dry pipe systems.

(B) Where it can be demonstrated that the detection system activating the preaction system will cause water to be at the sprinklers when they operate, preaction systems shall be permitted to be treated as wet pipe systems.

12.3.3.2.3.6 The nominal diameter of branch line pipes (including riser nipples) shall meet the following:

(1) Pipe diameter shall not be not less than 1¼ in. (33 mm) nor greater than 2 in. (51 mm).
(2) Starter pieces shall be permitted to be 2½ in. (64 mm).
(3) Where branch lines are larger than 2 in. (51 mm), the sprinkler shall be supplied by a riser nipple to elevate the sprinkler 13 in. (330 mm) for 2½-in. (64-mm) pipe and 15 in. (380 mm) for 3-in. (76-mm) pipe. These dimensions are measured from the centerline of the pipe to the deflector. In lieu of this, sprinklers shall be permitted to be offset horizontally a minimum of 12 in. (305 mm).

12.3.3.2.3.7 Building steel shall not require special protection where Table 12.3.3.2.1(a) and Table 12.3.3.2.1(b) is applied as appropriate for the storage configuration.

12.3.3.3* Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.3.3.1 Protection of single-, double-, and multiple-row rack storage of cartoned or uncartoned unexpanded plastic and cartoned expanded plastic shall be in accordance with Table 12.3.3.3.1.

12.3.3.3.1.1 ESFR protection as defined shall not apply to the following:

(1) Rack storage involving solid shelves
(2) Rack storage involving combustible, open-top cartons or containers

12.3.3.3.2 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 12.3.3.3.1 for type of storage, commodity, storage height, and building height involved.

12.3.3.3.3 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines. The design shall include a minimum of 960 ft^2 (89 m^2).

12.3.3.3.4 Where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers for one of the levels shall be included with those of the other level in the hydraulic calculations.

12.3.3.4 In-Rack Sprinklers for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.3.4.1 In-Rack Sprinkler Location for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height. In-rack sprinklers shall be installed in accordance with Figure 12.3.3.1.5(a) through Figure 12.3.3.1.5(f).

12.3.3.4.2 In-Rack Sprinkler Spacing for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.3.4.2.1 In-Rack Sprinkler Clearance. The minimum of 6-in. (152.4-mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

12.3.3.4.2.2 The spacing of in-rack sprinklers shall be in accordance with Figure 12.3.3.1.5(a) and Figure 12.3.3.1.5(f).

12.3.3.4.3 In-Rack Sprinkler Water Demand for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height. The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote sprinklers as follows:

(1) Eight sprinklers where only one level is installed in racks
(2) Fourteen sprinklers (seven on each top two levels) where more than one level is installed in racks

12.3.3.4.4 In-Rack Sprinkler Discharge Pressure for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height. Sprinklers in racks shall discharge at not less than 15 psi (1 bar) for all classes of commodities. *(See Section C.19.)*

12.3.3.5 Special Design for Rack Storage of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height.

12.3.3.5.1 Slatted Shelves.

12.3.3.5.1.1* Slatted shelves shall be considered equivalent to solid shelves where the requirements of 12.3.3.5.1 are not met. *(See Section C.20.)*

12.3.3.5.1.2 A wet pipe system that is designed to provide a minimum of 0.6 gpm/ft^2 (24.5 mm/min) density over a minimum area of 2000 ft^2 (186 m^2) or K-14.0 ESFR sprinklers operating at a minimum of 50 psi (3.5 bar), K-16.8 sprinklers operating at a minimum of 32 psi (1.7 bar), or K-25.2 ESFR sprinklers operating at a minimum of 15 psi shall be permitted to protect single-row and double-row slatted-shelf racks where all of the following conditions are met:

(1) Sprinklers shall be K-11.2, K-14.0, or K-16.8 orifice spray sprinklers with a temperature rating of ordinary, intermediate, or high and shall be listed for storage occupancies or shall be K-14.0, K-16.8, or K-25.2 ESFR.

Table 12.3.3.3.1 ESFR Protection of Rack Storage without Solid Shelves of Plastics Commodities Stored Up to and Including 25 ft (7.6 m) in Height

Storage Arrangement	Commodity	Maximum Storage Height		Maximum Ceiling/ Roof Height		Nominal K-Factor	Orientation	Minimum Operating Pressure		In-Rack Sprinkler Requirements	Hose Stream Demand		Water Supply Duration (hours)
		ft	m	ft	m			psi	bar		gpm	L/min	
Single-row, double-row and multiple-row rack (no open-top containers)	Cartoned unexpanded	20	6.1	25	7.6	11.2	Upright	50	3.4	No	250	946	1
						14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
						25.2	Pendent	15	1.0	No			
				30	9.1	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
						25.2	Pendent	15	1.0	No			
				35	10.7	14.0	Upright or pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	20	1.4	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			
		25	7.6	30	9.1	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
						25.2	Pendent	15	1.0	No			
				32	9.8	14.0	Upright or pendent	60	4.1	No			
						16.8	Pendent	42	2.9	No			
				35	10.7	14.0	Upright or pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	20	1.4	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			

12.3.3.3.1 ***Continued***

Storage Arrangement	Commodity	Maximum Storage Height ft	Maximum Storage Height m	Maximum Ceiling/Roof Height ft	Maximum Ceiling/Roof Height m	Nominal K-Factor	Orientation	Minimum Operating Pressure psi	Minimum Operating Pressure bar	In-Rack Sprinkler Requirements	Hose Stream Demand gpm	Hose Stream Demand L/min	Water Supply Duration (hours)
Single-row, double-row and multiple-row rack (no open-top containers)	Exposed unexpanded	20	6.1	25	7.6	14.0	Pendent	50	3.4	No	250	946	1
						16.8	Pendent	35	2.4	No			
				30	9.1	14.0	Pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
				35	10.7	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
		25	7.6	30	9.1	14	Pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
				32	9.8	14.0	Pendent	60	4.1	No			
						16.8	Pendent	42	2.9	No			
				35	10.7	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
	Cartoned expanded	20	6.1	25	7.6	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
				30	9.1	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
		25	7.6	30	9.1	14.0	Upright or pendent	50	3.4	No			
						16.8	Pendent	35	2.4	No			
				32	9.8	14.0	Pendent	60	4.1	No			
						16.8	Pendent	42	2.9	No			

(2) The protected commodities shall be limited to Class I-IV, Group B plastics, Group C plastics, cartoned (expanded and unexpanded) Group A plastics, and exposed (unexpanded) Group A plastics.
(3) Shelves shall be slatted using a minimum nominal 2-in. (51-mm) thick by maximum nominal 6-in. (152-mm) wide slat held in place by spacers that maintain a minimum 2-in. (51-mm) opening between each slat.
(4) Where K-11.2, K-14.0, or K-16.8 orifice sprinklers are used, there shall be no slatted shelf levels in the rack above 12 ft (3.7 m). Wire mesh (greater than 50 percent opening) shall be permitted for shelf levels above 12 ft (3.7 m).
(5) Transverse flue spaces at least 3 in. (76 mm) wide shall be provided at least every 10 ft (3.1 m) horizontally.
(6) Longitudinal flue spaces at least 6 in. (152 mm) wide shall be provided for double-row racks. Longitudinal flue spaces shall not be required when ESFR sprinklers are used.
(7) The aisle widths shall be at least 7½ ft (2.3 m).
(8) The maximum roof height shall be 27 ft (8.2 m) or 30 ft where ESFR sprinklers are used.
(9) The maximum storage height shall be 20 ft (6.1 m).
(10) Solid plywood or similar materials shall not be placed on the slatted shelves so that they block the 2-in. (51-mm) spaces between slats, nor shall they be placed on the wire mesh shelves.

12.3.4 Protection Criteria for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.1.1* For single- and double-row racks, the water demand for nonencapsulated storage without solid shelves separated by aisles at least 4 ft (1.2 m) wide and with not more than 10 ft (3.1 m) between the top of storage and the sprinklers shall be based on sprinklers in a 2000-ft² (186-m²) operating area, discharging a minimum of 0.25 gpm/ft² (10.2 mm/min) for Class I commodities, 0.3 gpm/ft² (12.2 mm/min) for Classes II and III commodities, and 0.35 gpm/ft² (14.3 mm/min) for Class IV commodities for ordinary temperature–rated sprinklers or a minimum of 0.35 gpm/ft² (14.3 mm/min) for Class I commodities, 0.4 gpm/ft² (16.3 mm/min) for Classes II and III commodities, and 0.45 gpm/ft² (18.3 mm/min) for Class IV commodities for high temperature–rated sprinklers. *(See Table 12.3.4.1.1 and Section C.23.)*

12.3.4.1.2 Where storage as described in 12.3.4.1.1 is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated storage.

12.3.4.1.3 For multiple-row racks, the water demand for nonencapsulated storage without solid shelves separated by aisles at least 4 ft (1.2 m) wide and with not more than 10 ft (3.1 m) between the top of storage and the sprinklers shall be based on sprinklers in a 2000-ft² (186-m²) operating area for multiple-row racks, discharging a minimum of 0.25 gpm/ft² (10.2 mm/min) for Class I commodities, 0.3 gpm/ft² (12.2 mm/min) for Classes II and III commodities, and 0.35 gpm/ft² (14.3 mm/min) for Class IV commodities for ordinary temperature–rated sprinklers or a minimum of 0.35 gpm/ft² (14.3 mm/min) for Class I commodities, 0.4 gpm/ft² (16.3 mm/min) for Classes II and III commodities, and 0.45 gpm/ft² (18.3 mm/min) for Class IV commodities for high temperature–rated sprinklers. *(See Table 12.3.4.1.3.)*

12.3.4.1.4 Where such storage is encapsulated, ceiling sprinkler density shall be 25 percent greater than for nonencapsulated storage.

12.3.4.1.5 The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 12.3.4.1.5 to the water supply for sprinklers determined in 12.3.4. This supply shall be available for the minimum duration specified in Table 12.3.4.1.5.

12.3.4.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.2.1 Protection of single-, double-, and multiple-row rack storage without solid shelves for Classes I through IV commodities shall be in accordance with Table 12.3.4.2.1.

12.3.4.2.2 Where in-rack sprinklers are required by Table 12.3.4.2.1, in-rack sprinkler spacing, design pressure, and hydraulic calculation criteria shall be in accordance with the requirements of 12.3.4.4 as applicable for the commodity.

12.3.4.2.3 Protection shall be provided as specified in Table 12.3.4.2.1 or appropriate NFPA standards in terms of minimum operating pressure and the number of sprinklers to be included in the design area.

12.3.4.2.3.1 For design purposes, 95 psi (6.6 bar) shall be the maximum discharge pressure at the hydraulically most remote sprinkler.

12.3.4.2.3.2 Open Wood Joist Construction.

(A) Where large drop K-11.2 sprinklers are installed under open wood joist construction, their minimum operating pressure shall be 50 psi (3.4 bar).

(B) Where each joist channel of open, wood joist construction is fully fire-stopped to its full depth at intervals not exceeding 20 ft (6.1 m), the lower pressures specified in Table 12.3.4.2.1 shall be permitted to be used.

12.3.4.2.3.3 The design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area protected by the number of sprinklers to be included in the design area. Any fractional sprinkler shall be included in the design area.

12.3.4.2.3.4 Hose stream demand and water supply duration requirements shall be in accordance with Table 12.3.4.2.1.

12.3.4.2.3.5 Preaction Systems.

(A) For the purpose of using Table 12.3.4.2.1, preaction systems shall be classified as dry pipe systems.

(B) Where it can be demonstrated that the detection system activating the preaction system will cause water to be at the sprinklers when they operate, preaction systems shall be permitted to be treated as wet pipe systems.

12.3.4.2.3.6 The nominal diameter of branch line pipes (including riser nipples) shall meet the following:

(1) Pipe diameter shall not be not less than 1¼ in. (33 mm) nor greater than 2 in. (51 mm).
(2) Starter pieces shall be permitted to be 2½ in. (64 mm).
(3) Where branch lines are larger than 2 in. (51 mm), the sprinkler shall be supplied by a riser nipple to elevate the sprinkler 13 in. (330 mm) for 2½-in. (64-mm) pipe and 15 in. (380 mm) for 3-in. (76-mm) pipe. These dimensions are measured from the centerline of the pipe to the deflector. In lieu of this, sprinklers shall be permitted to be offset horizontally a minimum of 12 in. (305 mm).

Table 12.3.4.1.1 Double-Row Racks without Solid Shelves, of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height, Aisles 4 ft (1.2 m) or Wider

Commodity Class	In-Rack Sprinklers Approximate Vertical Spacing at Tier Nearest the Vertical Distance and Maximum Horizontal Spacing[1,2,3]					Ceiling Sprinkler Operating Area		Ceiling Sprinkler Density Clearance up to 10 ft (3.1 m)[7,8,9]			
								Ordinary Temperature		High Temperature	
	Longitudinal Flue[4]	Face[5,6]	Figure	Maximum Storage Height	Stagger	ft^2	m^2	gpm/ft^2	mm/min	gpm/ft^2	mm/min
I	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.1 m) under horizontal barriers	None	12.3.4.4.1.1(a)	30 ft (9.1 m)	No	2000	186	0.25	10.2	0.35	14.3
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.1 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.1 m)	12.3.4.4.1.1(b)	Higher than 25 ft (7.6 m)	Yes			0.25	10.2	0.35	14.3
I, II, III	Vertical 10 ft (3.1 m) or at 15 ft (4.6 m) and 25 ft (7.6 m)	None	12.3.4.4.1.1(c)	30 ft (9.1 m)	Yes	2000	186	0.3	12.2	0.4	16.3
	Vertical 10 ft (3.1 m) Horizontal 10 ft (3.1 m)	Vertical 30 ft (9.1 m) Horizontal 10 ft (3.1 m)	12.3.4.4.1.1(d)	Higher than 25 ft. (7.6 m)	Yes			0.3	12.2	0.4	16.3
	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.1 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	12.3.4.4.1.1(e)		Yes			0.3	12.2	0.4	16.3
	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	Vertical 25 ft (7.6 m) Horizontal 5 ft (1.5 m)	12.3.4.4.1.1(f)		No			0.3	12.2	0.4	16.3
	Horizontal barriers at 20 ft (6.1 m) Vertical intervals — two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.1 m), staggered		12.3.4.4.1.1(g)		Yes			0.3	12.2	0.4	16.3
I, II, III, IV	Vertical 15 ft (4.6 m) Horizontal 10 ft (3.1 m)	Vertical 20 ft (6.1 m) Horizontal 10 ft (3.1 m)	12.3.4.4.1.1(h)	Higher than 25 ft (7.6 m)	Yes	2000	186	0.35	14.3	0.45	18.3
	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	Vertical 20 ft (6.1 m) Horizontal 5 ft (1.5 m)	12.3.4.4.1.1(i)		No			0.35	14.3	0.45	18.3
	Horizontal barriers at 15 ft (4.6 m) Vertical intervals — two lines of sprinklers under barriers — maximum horizontal spacing 10 ft (3.1 m), staggered		12.3.4.4.1.1(j)		Yes			0.35	14.3	0.45	18.3

[1] Minimum in-rack sprinkler discharge, 30 gpm (114 L/min).
[2] Water shields required.
[3] All in-rack sprinkler spacing dimensions start from the floor.
[4] Install sprinklers at least 3 in. (76.2 mm) from uprights.
[5] Face sprinklers shall not be required for a Class I commodity consisting of noncombustible products on wood pallets (without combustible containers), except for arrays shown in Figure 12.3.4.4.1.1(g)and Figure 12.3.4.4.1.1(j).
[6] In Figure 12.3.4.4.1.1(a) through Figure 12.3.4.4.1.1(j), each square represents a storage cube that measures 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (0.46 m to 3.1 m). Therefore, there can be one load to six or seven loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.
[7] For encapsulated commodity, increase density 25 percent.
[8] Clearance is distance between top of storage and ceiling.
[9] See A.12.3.1.12 for protection recommendations where clearance is greater than 10 ft (3.1 m).

Table 12.3.4.1.3 Multiple-Row Racks, of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Class	Encapsulated	In-Rack Sprinklers[1,2,3] Approximate Vertical Spacing ft	m	Maximum Horizontal Spacing in A Flue ft	m	Maximum Horizontal Spacing across Flue ft	m	Height Limit (ft)	Stagger	Figure	Maximum Spacing from Top of Storage to Highest In-Rack Sprinklers ft	m	Ceiling Sprinkler Operating Area ft²	m²	Ceiling Sprinklers Density 165° Rating gpm/ft²	mm/min	286° Rating gpm/ft²	mm/min
I	No	20	6.1	12	3.7	10	3.1			12.3.4.4.1.3(a)	10	3.1			0.25	10.2	0.35	14.3
	Yes														0.31		0.44	
I, II, and III	No	15	4.6	10	3.1	10	3.1	None	Between adjacent flues	12.3.4.4.1.3(b)	10	3.1	2000	186	0.30	12.2	0.40	16.3
	Yes														0.37		0.50	20.4
I, II, III, and IV	No	10	3.1	10	3.1	10	3.1			12.3.4.4.1.3(c)	5	1.5			0.35	14.3	0.45	18.3
	Yes														0.44		0.56	

Notes: For SI units, °C = $\frac{5}{9}$ (°F–32); 1 gpm/ft² = 40.746 mm/min.
[1]All four rack faces shall be protected by sprinklers located within 18 in. (0.46 m) of the faces, as indicated in Figure 12.3.4.4.1.3(a) through Figure 12.3.4.4.1.3(c). It shall not be required for each sprinkler level to protect all faces.
[2]All in-rack sprinkler spacing dimensions start from the floor.
[3]In Figure 12.3.4.4.1.3(a) through Figure 12.3.4.4.1.3(c), each square represents a storage cube measuring 4 ft to 5 ft (1.2 m to 1.5 m) on a side. Actual load heights can vary from approximately 18 in. to 10 ft (0.46 m to 3.1 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.1 m) apart vertically.

Table 12.3.4.1.5 Hose Stream Demand and Water Supply Duration Requirements for Rack Storage of Class I through Class IV Commodities Stored Above 25 ft (7.6 m) in Height

Commodity Classification	Storage Height ft	m	Inside Hose gpm	L/min	Total Combined Inside and Outside Hose gpm	L/min	Duration (minutes)
Class I, II, and III	>25	>7.6	0, 50, or 100	0, 190, 380	500	1900	90
Class IV	>25	>7.6	0, 50, or 100	0, 190, 380	500	1900	120

Table 12.3.4.2.1 Large Drop Sprinkler Design Criteria for Single-, Double-, and Multiple-Row Racks without Solid Shelves of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Commodity Class	Nominal K-Factor	Maximum Storage Height ft	m	Maximum Ceiling/ Roof Height ft	m	Type of System	Number of Design Sprinklers/ Minimum Pressure #/psi	#/bar	Hose Stream Demand gpm	L/min	Water Supply Duration (hours)
I, II	11.2	30	9.1	35	10.7	Wet	20/25 + 1 level of in-rack	20/1.7 + 1 level of in-rack	500	1900	1½
						Dry	30/25 + 1 level of in-rack	30/1.7 + 1 level of in-rack	500	1900	1½
III, IV	Design criteria not applicable to Class III or Class IV commodities stored in excess of 25 ft (7.6 m) in height										

12.3.4.2.3.7 Building steel shall not require special protection where Table 12.3.4.2.1 is applied as appropriate for the storage configuration.

12.3.4.3* Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.3.1 Protection of single-, double-, and multiple-row rack storage of Classes I through IV shall be in accordance with Table 12.3.4.3.1.

12.3.4.3.1.1 ESFR protection as defined shall not apply to the following:

(1) Rack storage involving solid shelves
(2) Rack storage involving combustible, open-top cartons or containers

12.3.4.3.2 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 12.3.4.3.1 for type of storage, commodity, storage height, and building height involved.

Table 12.3.4.3.1 ESFR Protection of Rack Storage without Solid Shelves of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height

Storage Arrangement	Commodity	Maximum Storage Height ft	Maximum Storage Height m	Maximum Ceiling/ Roof Height ft	Maximum Ceiling/ Roof Height m	Nominal K-Factor	Orientation	Minimum Operating Pressure psi	Minimum Operating Pressure bar	In-Rack Sprinkler Requirements	Hose Stream Demand gpm	Hose Stream Demand L/min	Water Supply Duration (hours)
Single-row, double-row, and multiple-row rack (no open-top containers)	Class I, II, III, or IV, encapsulated or unencapsulated	30	9.1	35	10.7	14.0	Upright or pendent	75	5.2	No	250	946	1
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	20	1.4	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			
		35	10.7	40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			
		40	12.2	45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			

12.3.4.3.3 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines. The design shall include a minimum of 960 ft^2 (89 m^2).

12.3.4.3.4 Where required by Table 12.3.4.3.1, one level of K-8.0 quick-response, ordinary-temperature in-rack sprinklers shall be installed at the tier level closest to but not exceeding ½ of the maximum storage height. In-rack sprinkler hydraulic design criteria shall be the most hydraulically remote eight sprinklers at 50 psi (3.4 bar). In-rack sprinklers shall be located at the intersection of the longitudinal and transverse flue space. Horizontal spacing shall not be permitted to exceed 5-ft (1.5-m) intervals.

12.3.4.3.5 Where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers for one of the levels shall be included with those of the other level in the hydraulic calculations.

12.3.4.4 In-Rack Sprinklers for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

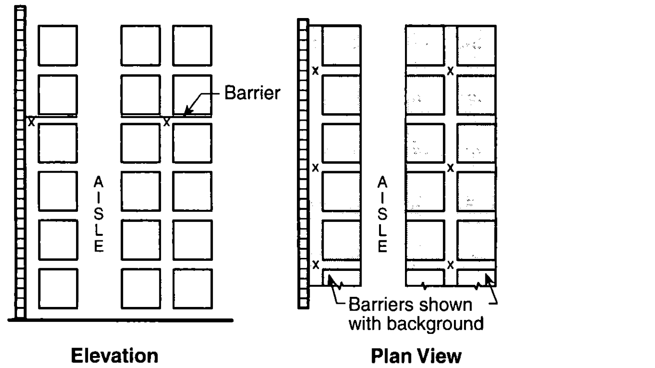
12.3.4.4.1 In-Rack Sprinkler Location for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.4.1.1* Double-Row Racks.

(A) In double-row racks without solid shelves and with a maximum of 10 ft (3.1 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with Table 12.3.4.1.1 and Figure 12.3.4.4.1.1(a) through Figure 12.3.4.4.1.1(j). The highest level of in-rack sprinklers shall be not more than 10 ft (3.1 m) below the top of storage. Where a single-row rack is mixed with double-row racks, Table 12.3.4.1.1 and Figure 12.3.4.4.1.1(a) through Figure 12.3.4.4.1.1(j) shall be used.

(B) Figure 12.3.4.4.1.2(a) through Figure 12.3.4.4.1.2(c) shall be permitted to be used for the protection of the single-row racks.

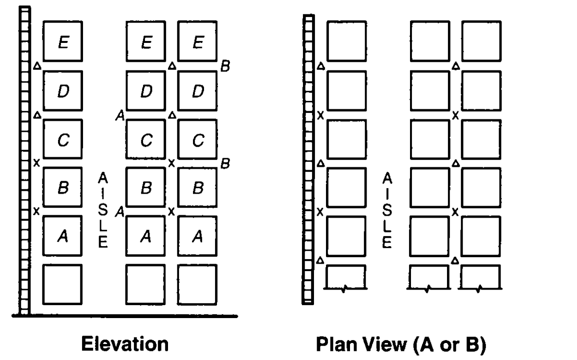
12.3.4.4.1.2* Single-Row Racks. In single-row racks without solid shelves with storage height over 25 ft (7.6 m) and a maximum of 10 ft (3.1 m) between the top of storage and the ceiling, sprinklers shall be installed in accordance with Figure 12.3.4.4.1.2(a) through Figure 12.3.4.4.1.2(e). In single-row racks, where figures show in-rack sprinklers in transverse flue spaces centered between the rack faces, it shall be permitted to position these in-rack sprinklers in the transverse flue at any point between the load faces.



Notes:

1. Symbol x indicates in-rack sprinklers.
2. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

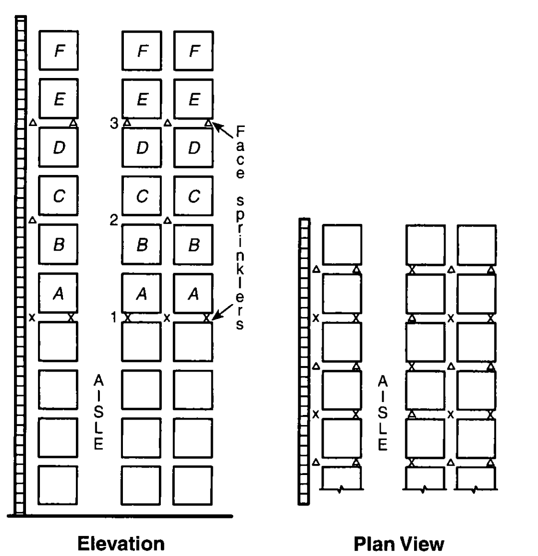
FIGURE 12.3.4.4.1.1(a) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).



Notes:

1. Alternate location of in-rack sprinklers. Sprinklers shall be permitted to be installed above loads *A* and *C* or above loads *B* and *D*.
2. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

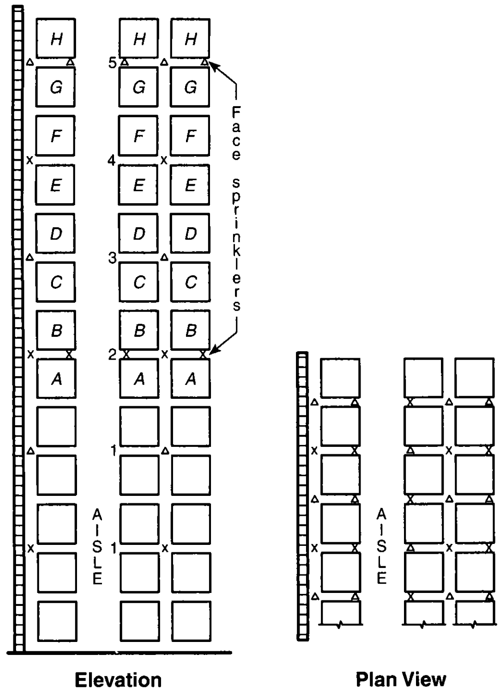
FIGURE 12.3.4.4.1.1(c) In-Rack Sprinkler Arrangement, Class I, Class II, or Class III Commodities, Storage Height 25 ft to Maximum 30 ft (7.6 m to Maximum 9.1 m).



Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *E* or *F* represent top of storage.
4. For storage higher than represented by loads labeled *F*, the cycle defined by Notes 2 and 3 is repeated, with stagger as indicated.
5. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

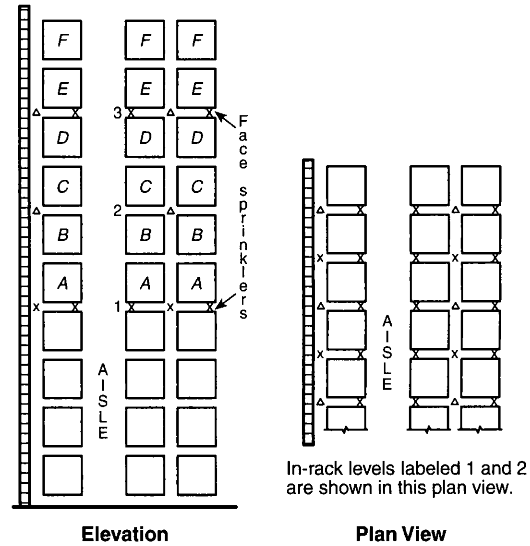
FIGURE 12.3.4.4.1.1(b) In-Rack Sprinkler Arrangement, Class I Commodities, Storage Height Over 25 ft (7.6 m).



Notes:

1. Sprinklers labeled 1 shall be required where loads labeled *A* represent the top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *B* or *C* represent top of storage.
3. Sprinklers labeled 1, 2, and 3 shall be required where loads labeled *D* or *E* represent top of storage.
4. Sprinklers labeled 1, 2, 3, and 4 shall be required where loads labeled *F* or *G* represent top of storage.
5. Sprinklers labeled 1, 2, 3, 4, and 5 shall be required where loads labeled *H* represent top of storage.
6. For storage higher than represented by loads labeled *H*, the cycle defined by Notes 3, 4, and 5 is repeated with stagger as indicated.
7. The indicated face sprinklers shall be permitted to be omitted where commodity consists of unwrapped or unpackaged metal parts on wood pallets.
8. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
9. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

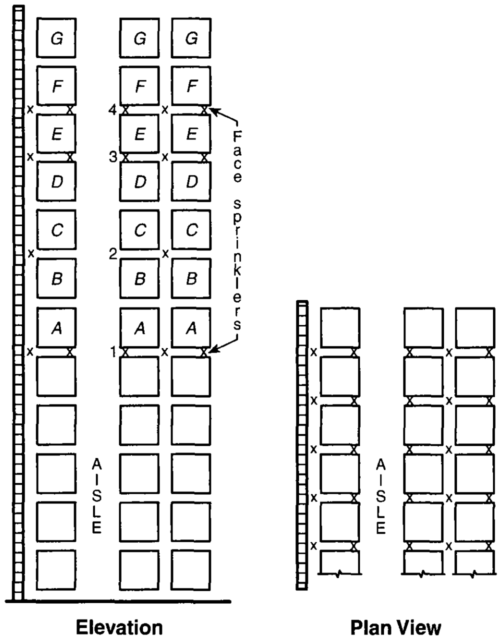
FIGURE 12.3.4.4.1.1(d) In-Rack Sprinkler Arrangement, Class I, Class II, or Class III Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *E* or *F* represent top of storage.
4. For storage higher than represented by loads labeled *F*, the cycle defined by Notes 2 and 3 is repeated, with stagger as indicated.
5. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

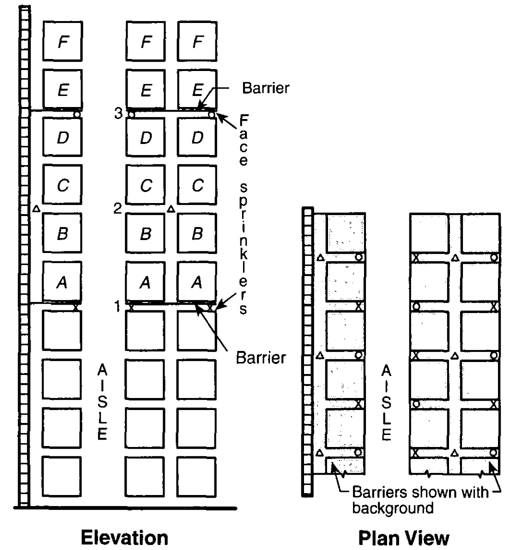
FIGURE 12.3.4.4.1.1(e) In-Rack Sprinkler Arrangement, Class I, Class II, or Class III Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *E* represent top of storage.
4. Sprinklers labeled 1 and 4 shall be required where loads labeled *F* or *G* represent top of storage.
5. For storage higher than represented by loads labeled *G*, the cycle defined by Notes 2, 3, and 4 is repeated.
6. Symbol x indicates face and in-rack sprinklers.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

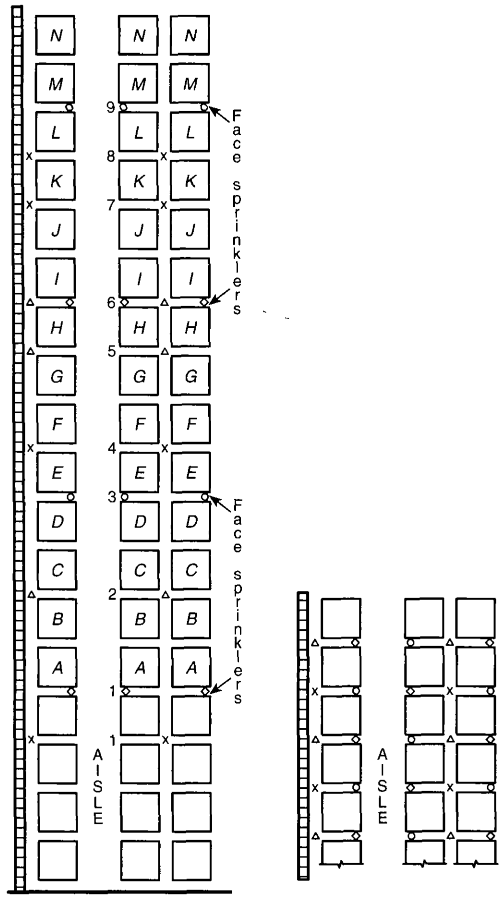
FIGURE 12.3.4.4.1.1(f) In-Rack Sprinkler Arrangement, Class I, Class II, or Class III Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *E* or *F* represent top of storage.
4. For storage higher than represented by loads labeled *F*, the cycle defined by Notes 2 and 3 is repeated.
5. Symbols o, Δ, and x indicate sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.1(g) In-Rack Sprinkler Arrangement, Class I, Class II, or Class III Commodities, Storage Height Over 25 ft (7.6 m) — Option 4.

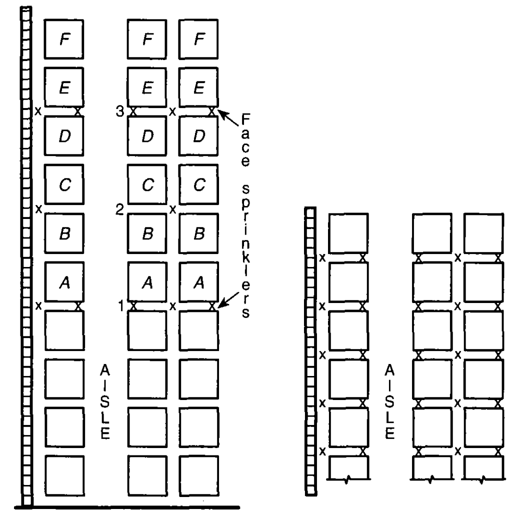


Elevation **Plan View**

Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1, 2, and 3 shall be required where loads labeled *E* or *F* represent top of storage.
4. Sprinklers labeled 1, 2, 3, and 4 shall be required where loads labeled *G* represent top of storage.
5. Sprinklers labeled 1, 2, 3, 4, and 5 shall be required where loads labeled *H* represent top of storage.
6. Sprinklers labeled 1, 2, 3, 4, and 6 (not 5) shall be required where loads labeled *I* or *J* represent top of storage.
7. Sprinklers labeled 1, 2, 3, 4, 6, and 7 shall be required where loads labeled *K* represent top of storage.
8. Sprinklers labeled 1, 2, 3, 4, 6, and 8 shall be required where loads labeled *L* represent top of storage.
9. Sprinklers labeled 1, 2, 3, 4, 6, 8, and 9 shall be required where loads labeled *M* or *N* represent top of storage.
10. For storage higher than represented by loads labeled *N*, the cycle defined by Notes 1 through 9 is repeated, with stagger as indicated. In the cycle, loads labeled *M* are equivalent to loads labeled *A*.
11. Symbols o, x, and Δ indicate sprinklers on vertical or horizontal stagger.
12. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.1(h) In-Rack Sprinkler Arrangement, Class I, Class II, Class III, or Class IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.

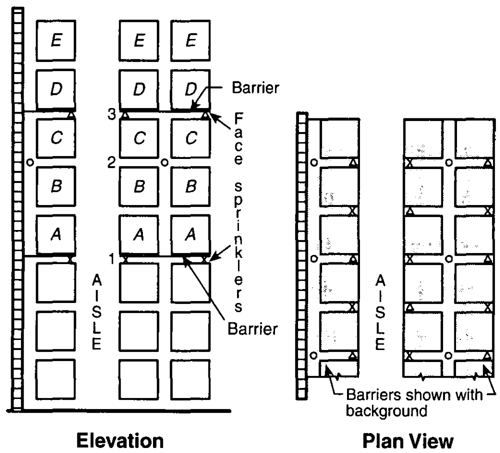


Elevation **Plan View (1 and 3)**

Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* or *D* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *E* or *F* represent top of storage.
4. For storage higher than represented by loads labeled *F*, the cycle defined by Notes 2 and 3 is repeated.
5. Symbol x indicates face and in-rack sprinklers.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

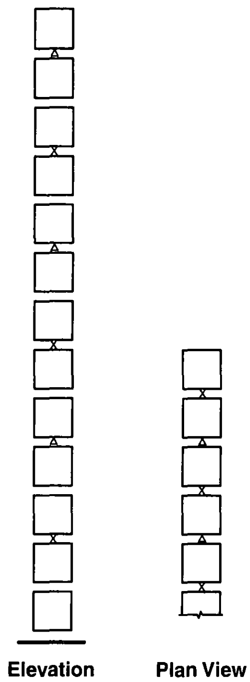
FIGURE 12.3.4.4.1.1(i) In-Rack Sprinkler Arrangement, Class I, Class II, Class III, or Class IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.



Notes:

1. Sprinklers labeled 1 (the selected array from Table 12.3.4.1.1) shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 and barrier labeled 1 shall be required where loads labeled *C* represent top of storage.
3. Sprinklers and barriers labeled 1 and 3 shall be required where loads labeled *D* or *E* represent top of storage.
4. For storage higher than represented by loads labeled *E*, the cycle defined by Notes 2 and 3 is repeated.
5. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Symbol o indicates longitudinal flue space sprinklers.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

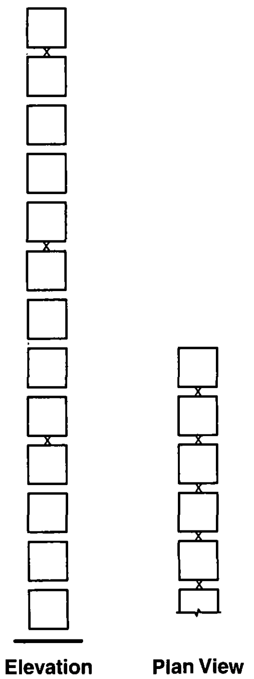
FIGURE 12.3.4.4.1.1(j) In-Rack Sprinkler Arrangement, Class I, Class II, Class III, or Class IV Commodities, Storage Height Over 25 ft (7.6 m) — Option 3.



Notes:

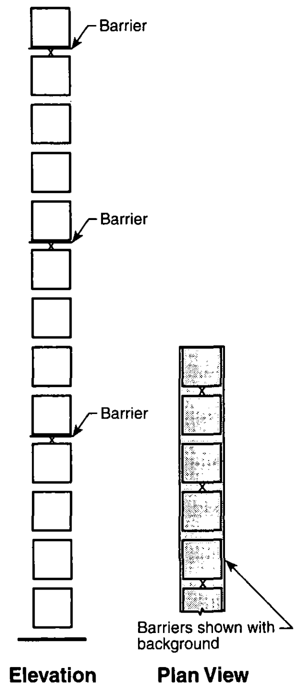
1. For all storage heights, sprinklers shall be installed in every other tier and staggered as indicated.
2. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
3. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.2(a) Class I, Class II, Class III, or Class IV Commodities, In-Rack Sprinkler Arrangement, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



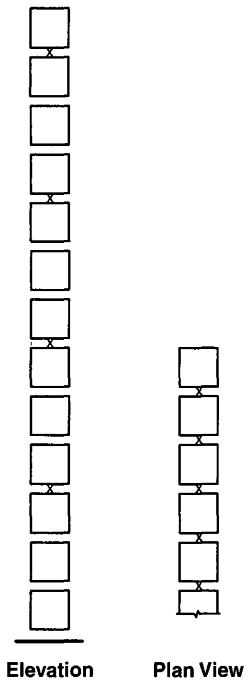
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.2(b) Class I, Class II, or Class III Commodities, In-Rack Sprinkler Arrangement, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



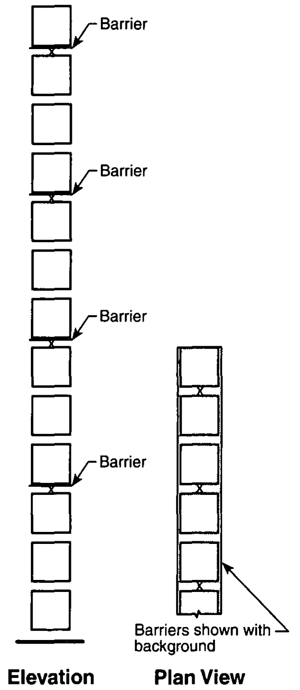
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.2(c) Class I, Class II, or Class III Commodities, In-Rack Sprinkler Arrangement, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

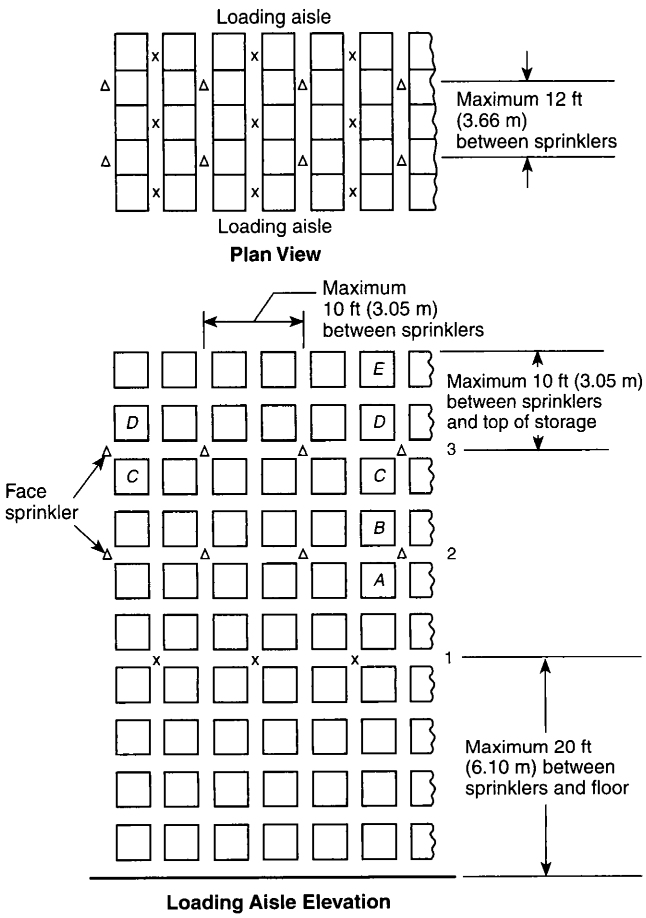
FIGURE 12.3.4.4.1.2(d) Class I, Class II, Class III, or Class IV Commodities, In-Rack Sprinkler Arrangement, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.2(e) Class I, Class II, Class III, or Class IV Commodities, In-Rack Sprinkler Arrangement, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.

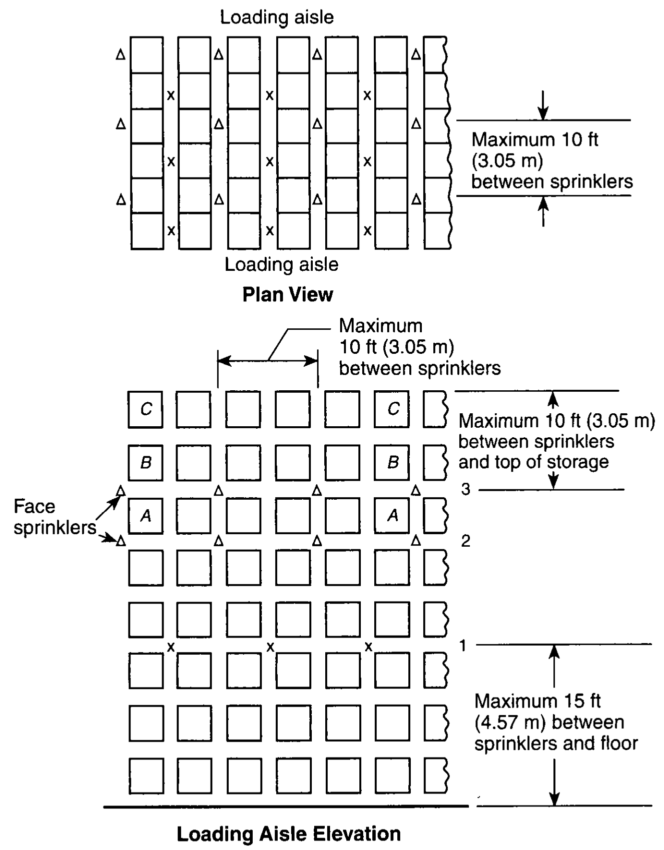
12.3.4.4.1.3* In-Rack Sprinkler Location — Multiple-Row Racks for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height. In multiple-row racks with a maximum of 10 ft (3.1 m) between the top of storage and the ceiling, protection shall be in accordance with Table 12.3.4.1.3 and in-rack sprinklers shall be installed as indicated in Figure 12.3.4.4.1.3(a) through Figure 12.3.4.4.1.3(c). The highest level of in-rack sprinklers shall be not more than 10 ft (3.1 m) below maximum storage height for Class I, Class II, or Class III commodities or 5 ft (1.5 m) below the top of storage for Class IV commodities.



Notes:

1. Sprinklers labeled 1 shall be required if loads labeled *A* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required if loads labeled *B* or *C* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required if loads labeled *D* or *E* represent top of storage.
4. For storage higher than represented by loads labeled *E*, the cycle defined by Notes 2 and 3 is repeated, with stagger as indicated.
5. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

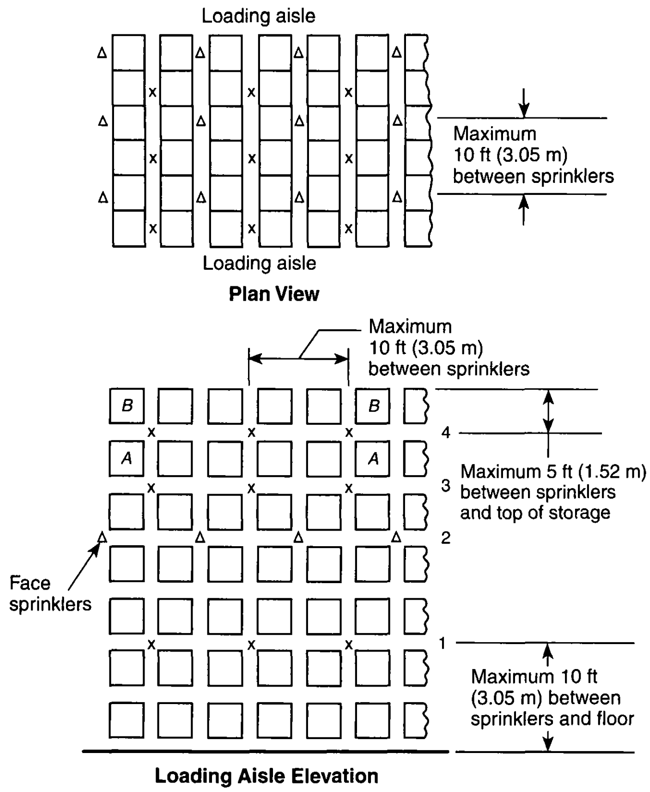
FIGURE 12.3.4.4.1.3(a) In-Rack Sprinkler Arrangement — Multiple-Row Racks, Class I Commodities, Storage Height Over 25 ft (7.6 m).



Notes:

1. Sprinklers labeled 1 and 2 shall be required if loads labeled *A* represent top of storage.
2. Sprinklers labeled 1 and 3 shall be required if loads labeled *B* or *C* represent top of storage.
3. For storage higher than represented by loads labeled *C*, the cycle defined by Notes 2 and 3 is repeated, with stagger as indicated.
4. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
5. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.3(b) In-Rack Sprinkler Arrangement — Multiple-Row Racks, Class I, Class II, or Class III Commodities, Storage Height Over 25 ft (7.6 m).



Notes:

1. Sprinklers labeled 1, 2, and 3 shall be required if loads labeled *A* represent top of storage.
2. Sprinklers labeled 1, 2, and 4 shall be required if loads labeled *B* represent top of storage.
3. For storage higher than represented by loads labeled *B*, the cycle defined by Notes 1 and 2 is repeated, with stagger as indicated.
4. Symbol Δ or x indicates sprinklers on vertical or horizontal stagger.
5. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.4.4.1.3(c) In-Rack Sprinkler Arrangement, Class I, Class II, Class III, or Class IV Commodities — Multiple-Row Racks, Storage Height Over 25 ft (7.6 m).

12.3.4.4.2 In-Rack Sprinkler Spacing for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.4.2.1 In-Rack Sprinkler Spacing. In-rack sprinklers shall be staggered horizontally and vertically where installed in accordance with Table 12.3.4.1.1, Figure 12.3.4.4.1.1(a) through Figure 12.3.4.4.1.1(j) and Figure 12.3.4.4.1.2(a) through Figure 12.3.4.4.1.2(e).

12.3.4.4.2.2 In-rack sprinklers for storage higher than 25 ft (7.6 m) in double-row racks shall be spaced horizontally and located in the horizontal space nearest the vertical intervals specified in Table 12.3.4.1.1 and Figure 12.3.4.4.1.1(a) through Figure 12.3.4.4.1.1(j).

12.3.4.4.2.3 In-Rack Sprinkler Spacing. Maximum horizontal spacing of sprinklers in multiple-row racks with storage higher than 25 ft (7.6 m) shall be in accordance with Figure 12.3.4.4.1.3(*a*) *through Figure* 12.3.4.4.1.3(*c*).

12.3.4.4.3 In-Rack Sprinkler Water Demand for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height. The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote sprinklers as follows:

(1) Six sprinklers where only one level is installed in racks with Class I, Class II, or Class III commodities
(2) Eight sprinklers where only one level is installed in racks with Class IV commodities
(3) Ten sprinklers (five on each two top levels) where more than one level is installed in racks with Class I, Class II, or Class III commodities
(4) Fourteen sprinklers (seven on each two top levels) where more than one level is installed in racks with Class IV commodities

12.3.4.4.4 In-Rack Sprinkler Discharge for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height. Sprinklers in racks shall discharge at a rate not less than 30 gpm (113.6 L/min) for all classes of commodities.

12.3.4.5 Special Design for Rack Storage of Class I through Class IV Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.4.5.1 High-Expansion Foam Systems. Where high-expansion foam is used in combination with ceiling sprinklers, the minimum ceiling sprinkler design density shall be 0.2 gpm/ft^2 (8.2 mm/min) for Class I, Class II, or Class III commodities and 0.25 gpm/ft^2 (10.2 mm/min) for Class IV commodities for the most hydraulically remote 2000-ft^2 (186-m^2) area.

12.3.4.5.1.1 Where high-expansion foam is used in combination with ceiling sprinklers, the minimum ceiling sprinkler design density shall be 0.2 gpm/ft^2 (8.2 mm/min) for Class I, Class II, or Class III commodities and 0.25 gpm/ft^2 (10.2 mm/min) for Class IV commodities for the most hydraulically remote 2000-ft^2 (186-m^2) operating area.

12.3.4.5.1.2 Where high-expansion foam systems are used for storage over 25 ft (7.6 m) high up to and including 35 ft (10.7 m) high, they shall be used in combination with ceiling sprinklers. The maximum submergence time for the high-expansion foam shall be 5 minutes for Class I, Class II, or Class III commodities and 4 minutes for Class IV commodities.

12.3.5 Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.5.1 Control Mode Density-Area Sprinkler Protection Criteria for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height for Single-, Double-, and Multiple-Row Racks.

12.3.5.1.1 Ceiling Sprinkler Water Demand. For Group A plastic commodities in cartons, encapsulated or nonencapsulated, ceiling sprinkler water demand in terms of density [gpm/ft^2 (mm/min)] and area of operation [ft^2 (m^2)] shall be selected from Table 12.3.5.1.1.

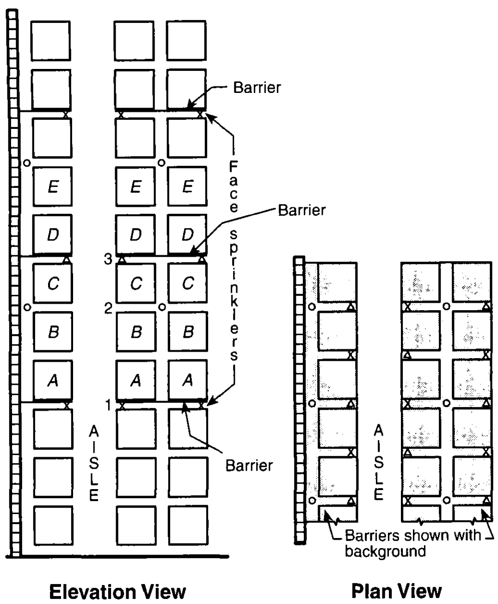
12.3.5.1.2 Where a single-row rack is mixed with double-row racks, either Figure 12.3.5.1.2(a) or Figure 12.3.5.1.2(b) shall be used in accordance with the corresponding storage height.

12.3.5.1.2.1 Figure 12.3.5.1.2.1(a) through Figure 12.3.5.1.2.1(c) shall be permitted to be used for the protection of the single-row racks.

12.3.5.1.3 The minimum water supply requirements for a hydraulically designed occupancy hazard fire control sprinkler system shall be determined by adding the hose stream demand from Table 12.3.5.1.3 to the water supply for sprinklers determined in 12.3.5. This supply shall be available for the minimum duration specified in Table 12.3.5.1.3.

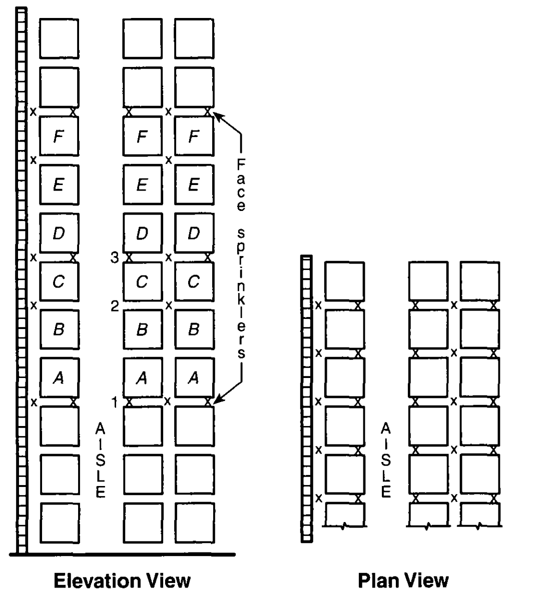
Table 12.3.5.1.1 Control Mode Density-Area Sprinkler Discharge Criteria for Single-, Double-, and Multiple-Row Racks of Plastics Commodities with Storage Over 25 ft (7.6 m) in Height

Storage Height above Top Level In-Rack Sprinklers	Ceiling Sprinklers Density (gpm/ft²)
5 ft or less	0.30/2000
Over 5 ft up to 10 ft	0.45/2000



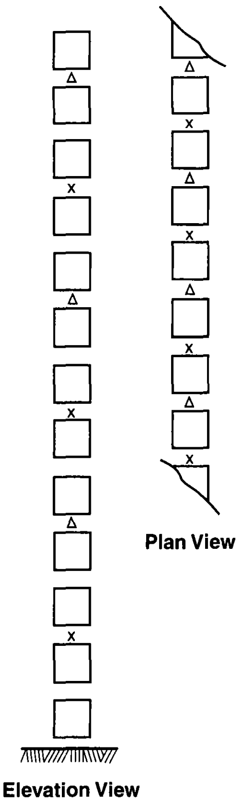
Notes:
1. Sprinklers and barriers labeled 1 shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 and barriers labeled 1 shall be required where loads labeled *C* represent top of storage.
3. Sprinklers and barriers labeled 1 and 3 shall be required where loads labeled *D* or *E* represent top of storage.
4. For storage higher than represented by loads labeled *E*, the cycle defined by Notes 2 and 3 is repeated.
5. Symbol Δ or x indicates face sprinklers on vertical or horizontal stagger.
6. Symbol o indicates longitudinal flue space sprinklers.
7. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.1.2(a) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Storage Height Over 25 ft (7.6 m) — Option 1.



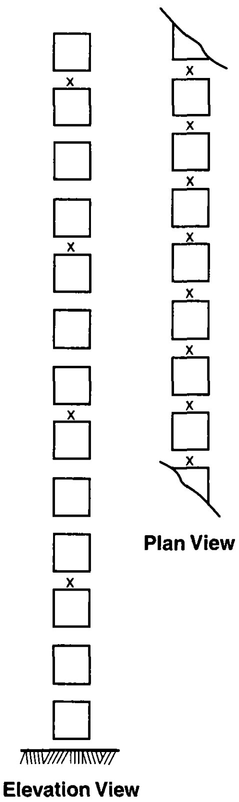
Notes:
1. Sprinklers labeled 1 shall be required where loads labeled *A* or *B* represent top of storage.
2. Sprinklers labeled 1 and 2 shall be required where loads labeled *C* represent top of storage.
3. Sprinklers labeled 1 and 3 shall be required where loads labeled *D* or *E* represent top of storage.
4. For storage higher than loads labeled *F*, the cycle defined by Notes 2 and 3 is repeated.
5. Symbol x indicates face and in-rack sprinklers.
6. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.1.2(b) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Storage Height Over 25 ft (7.6 m) — Option 2.



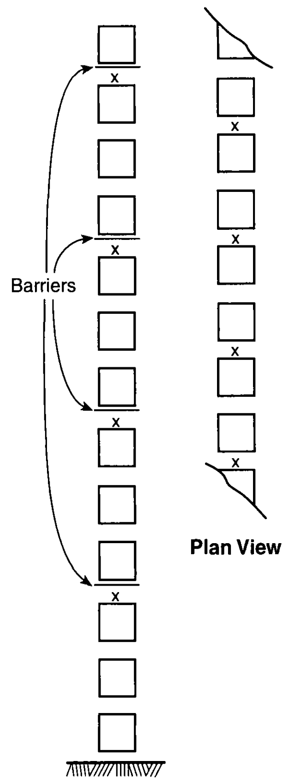
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.1.2.1(a) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05m) apart vertically.

FIGURE 12.3.5.1.2.1(b) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2.



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.1.2.1(c) In-Rack Sprinkler Arrangement, Group A Plastic Commodities, Single-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3.

12.3.5.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.5.3* Early Suppression Fast-Response (ESFR) Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.5.3.1 Protection of single-, double-, and multiple-row rack storage of cartoned or uncartoned unexpanded plastic and cartoned expanded plastic shall be in accordance with Table 12.3.5.3.1.

12.3.5.3.1.1 ESFR protection as defined shall not apply to the following:

(1) Rack storage involving solid shelves
(2) Rack storage involving combustible, open-top cartons or containers

12.3.5.3.2 ESFR sprinkler systems shall be designed such that the minimum operating pressure is not less than that indicated in Table 12.3.5.3.1 for type of storage, commodity, storage height, and building height involved.

12.3.5.3.3 The design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines. The design shall include a minimum of 960 ft^2 (89 m^2).

12.3.5.3.4 Where required by Table 12.3.5.3.1, one level of K-8.0 quick-response, ordinary-temperature in-rack sprinklers shall be installed at the tier level closest to but not exceeding ½ of the maximum storage height. In-rack sprinkler hydraulic design criteria shall be the most hydraulically remote eight sprinklers at 50 psi (3.4 bar). In-rack sprinklers shall be located at the intersection of the longitudinal and transverse flue space. Horizontal spacing shall not be permitted to exceed 5-ft (1.5-m) intervals.

12.3.5.3.5 Where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers for one of the levels shall be included with those of the other level in the hydraulic calculations.

12.3.5.4 In-Rack Sprinklers for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.5.4.1 In-Rack Sprinkler Location for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.5.4.1.1 In double-row racks without solid shelves and with a maximum of 10 ft (3.1 m) between the top of storage and the ceiling, in-rack sprinklers shall be installed in accordance with Figure 12.3.5.1.2(a) or Figure 12.3.5.1.2(b). The highest level of in-rack sprinklers shall be not more than 10 ft (3.1 m) below the top of storage.

12.3.5.4.1.2 In single-row racks without solid shelves with storage height over 25 ft (7.6 m) and a maximum of 10 ft (3.1 m) between the top of storage and the ceiling, sprinklers shall be installed as indicated in Figure 12.3.5.1.2.1(a), Figure 12.3.5.1.2.1(b), or Figure 12.3.5.1.2.1(c).

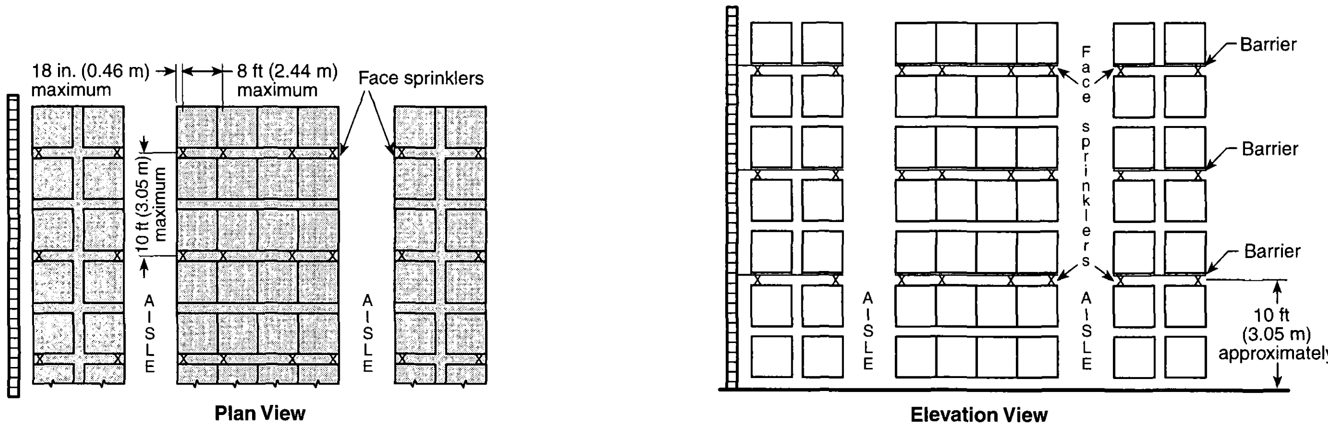
12.3.5.4.1.3* In multiple-row racks without solid shelves with storage height over 25 ft (7.6 m) and a maximum of 10 ft (3.1 m) between the top of storage and the roof/ceiling, in-rack sprinklers shall be installed as indicated in Figure 12.3.5.4.1.3(a) through Figure 12.3.5.4.1.3(f).

Table 12.3.5.1.3 Hose Stream Demand and Water Supply Duration Requirements for Rack Storage of Plastics Commodities Stored Above 25 ft (7.6 m) in Height

Commodity Classification	Storage Height		Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	ft	m	gpm	L/min	gpm	L/min	
Plastic	>25	>7.6	0, 50, 100	0, 190, 380	500	1900	120

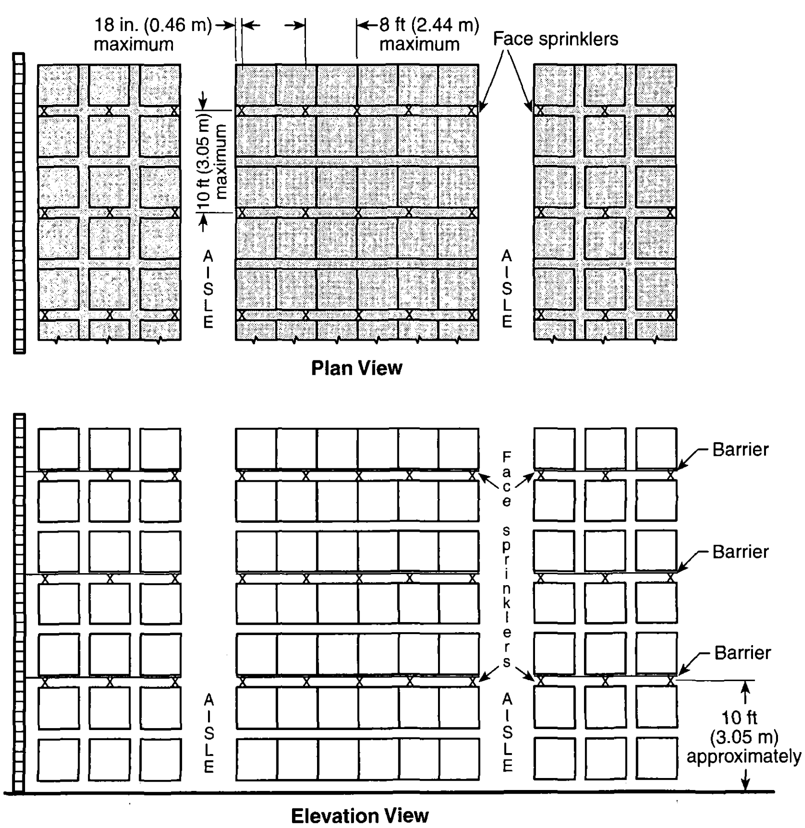
Table 12.3.5.3.1 ESFR Protection of Rack Storage without Solid Shelves of Plastics Commodities Stored Over 25 ft (7.6 m) in Height

Storage Arrangement	Commodity	Maximum Storage Height ft	Maximum Storage Height m	Maximum Ceiling/ Roof Height ft	Maximum Ceiling/ Roof Height m	Nominal K-Factor	Orientation	Minimum Operating Pressure psi	Minimum Operating Pressure bar	In-Rack Sprinkler Requirements	Hose Stream Demand gpm	Hose Stream Demand L/min	Water Supply Duration (hours)
Single-row, Double-row and Multiple-row Rack (No open-top containers)	Cartoned unexpanded	30	9.1	35	10.7	14.0	Upright or pendent	75	5.2	No	250	946	1
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	20	1.4	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			
		35	10.7	40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
						25.2	Pendent	25	1.7	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			
		40	12.2	45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
						25.2	Pendent	40	2.8	No			
	Exposed unexpanded	30	9.1	35	10.7	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
		35	10.7	40	12.2	14.0	Pendent	75	5.2	No			
						16.8	Pendent	52	3.6	No			
				45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			
		40	12.2	45	13.7	14.0	Pendent	90	6.2	Yes			
						16.8	Pendent	63	4.3	Yes			



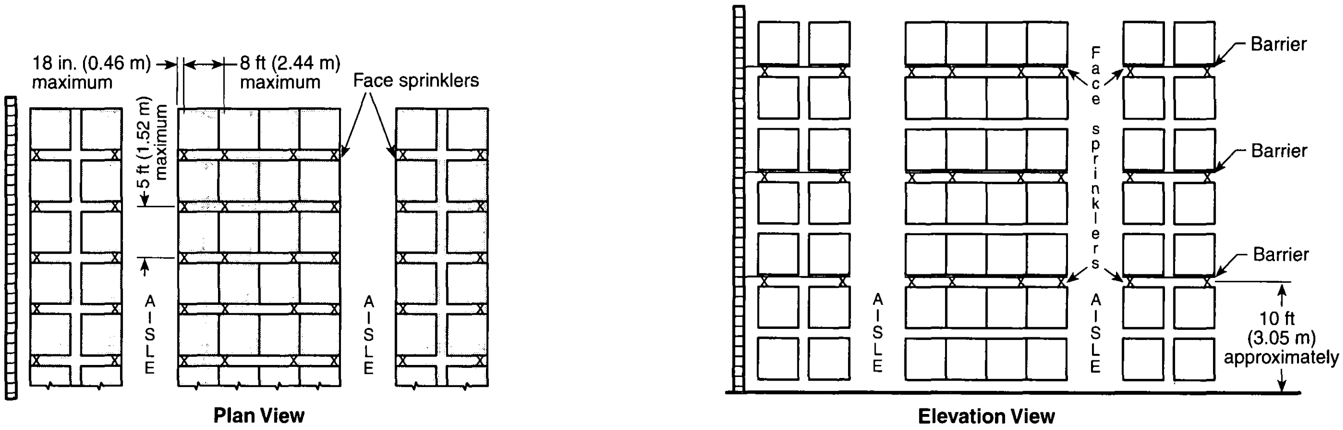
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(a) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 (10 ft Maximum Spacing).



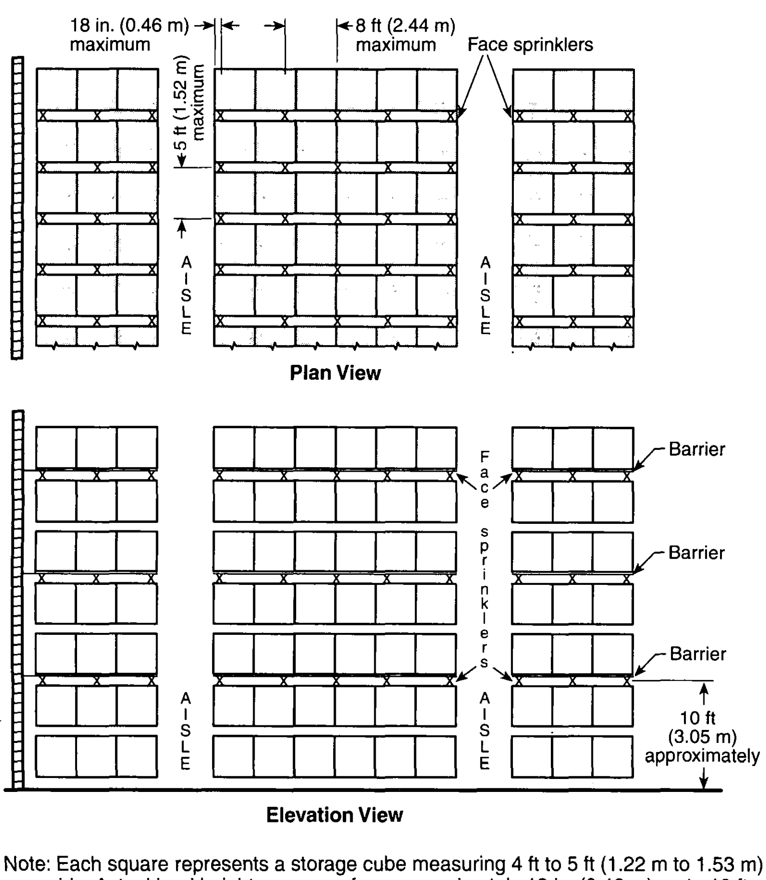
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(b) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 (10 ft Maximum Spacing).



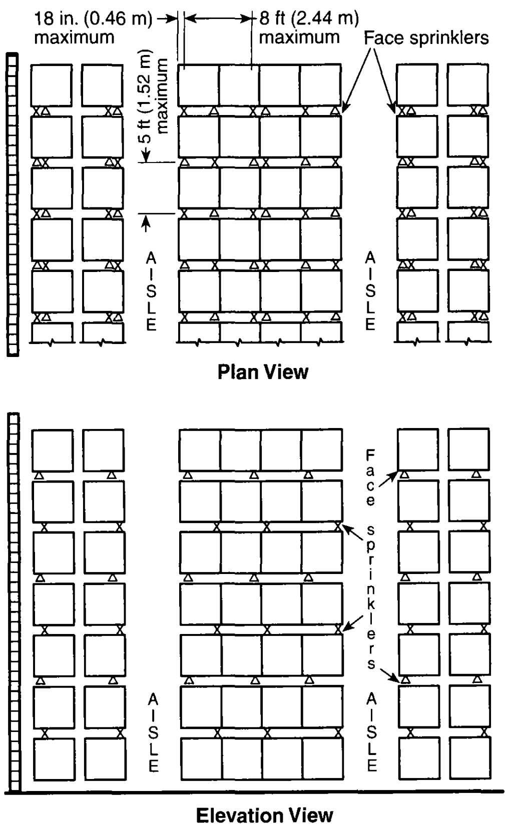
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(c) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 1 (5 ft Maximum Spacing).



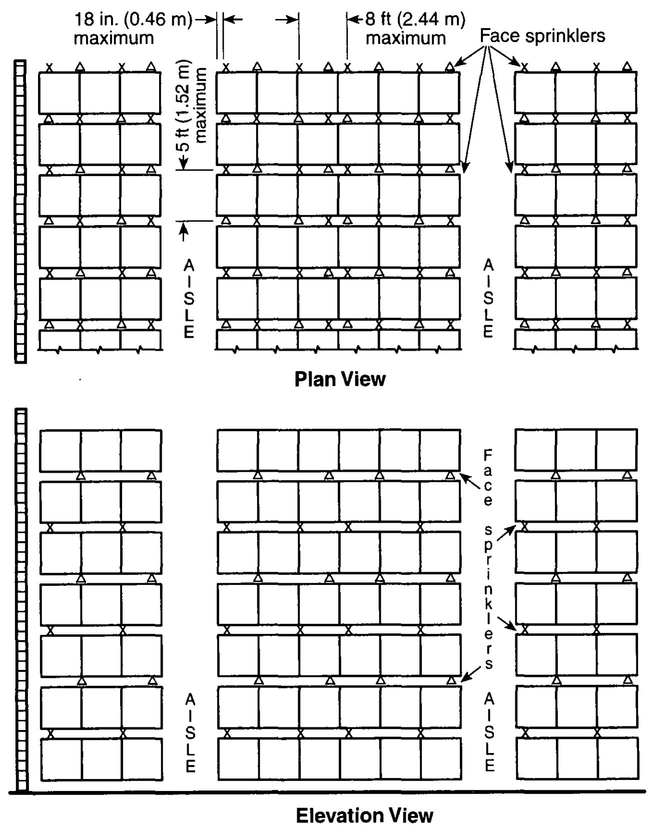
Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(d) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 2 (5 ft Maximum Spacing).



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

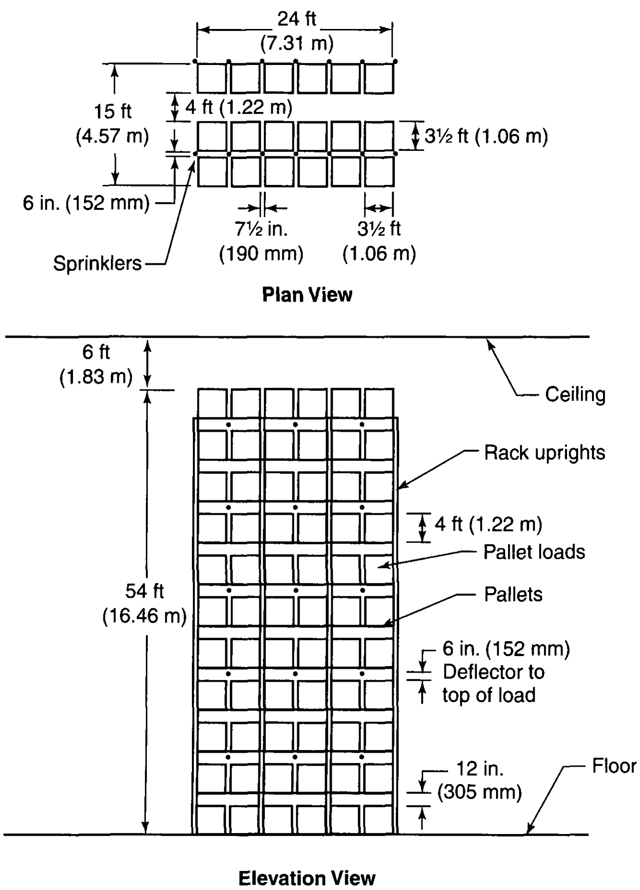
FIGURE 12.3.5.4.1.3(e) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 3 (5 ft Maximum Spacing).



Note: Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.3(f) In-Rack Sprinkler Arrangement, Cartoned Plastic and Uncartoned Unexpanded Plastic, Multiple-Row Racks, Storage Height Over 25 ft (7.6 m) — Option 4 (5 ft Maximum Spacing).

12.3.5.4.1.4 In single-row and double-row racks without solid shelves with storage height over 25 ft (7.6 m) with aisles greater than 4 ft (1.2 m), in-rack sprinklers shall be located in accordance with Figure 12.3.5.4.1.4 and the ceiling sprinklers shall be designed for 0.45 gpm/ft^2 over a minimum design area of 2000 ft^2.



Notes:
1. Sprinklers in alternate tiers at every transverse flue space.
2. Each square represents a storage cube measuring 4 ft to 5 ft (1.22 m to 1.53 m) on a side. Actual load heights can vary from approximately 18 in. (0.46 m) up to 10 ft (3.05 m). Therefore, there could be as few as one load or as many as six or seven loads between in-rack sprinklers that are spaced 10 ft (3.05 m) apart vertically.

FIGURE 12.3.5.4.1.4 In-Rack Sprinkler Arrangement, Cartoned Expanded and Unexpanded Plastic and Uncartoned Unexpanded Plastic Commodities, Single- and Double-Row Racks, Storage Height Over 25 ft (7.6 m).

12.3.5.4.2 In-Rack Sprinkler Spacing for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height.

12.3.5.4.2.1 In-rack sprinklers for storage higher than 25 ft (7.6 m) in double-row racks shall be spaced horizontally and shall be located in the horizontal space nearest the vertical intervals specified in Figure 12.3.5.1.2(a) or Figure 12.3.5.1.2(b).

12.3.5.4.2.2 The minimum of 6-in. (152.4-mm) vertical clear space shall be maintained between the sprinkler deflectors and the top of a tier of storage.

12.3.5.4.3 In-Rack Sprinkler Water Demand for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height. The water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote sprinklers as follows:

(1) Eight sprinklers where only one level is installed in racks
(2) Fourteen sprinklers (seven on each top two levels) where more than one level is installed in racks

12.3.5.4.4 In-Rack Sprinkler Discharge Pressure for Rack Storage of Plastics Commodities Stored Over 25 ft (7.6 m) in Height. Sprinklers in racks shall discharge at not less than 30 gpm (113.6 L/min).

12.4 Protection of Rubber Tire Storage.

12.4.1 General. The sprinkler system criteria of Section 12.4 shall apply to buildings with ceiling slopes not exceeding 2 in 12 (16.7 percent).

12.4.1.1 Columns within Rubber Tire Storage.

12.4.1.1.1 Where fireproofing is not provided, steel columns shall be protected as follows:

(1) Storage exceeding 15 ft through 20 ft (4.6 m through 6 m) in height — one sidewall sprinkler directed to one side of the column at a 15-ft (4.6-m) level
(2) Storage exceeding 20 ft (6.1 m) in height — two sidewall sprinklers, one at the top of the column and the other at a 15-ft (4.6-m) level, both directed to the side of the column

12.4.1.1.2 The flow from a column sprinkler(s) shall be permitted to be omitted from the sprinkler system hydraulic calculations.

12.4.1.2 The protection specified in 12.3.1.7, 12.4.1.1.1(1), and 12.4.1.1.1(2) shall not be required where storage in fixed racks is protected by in-rack sprinklers.

12.4.1.3 The protection specified in 12.4.1.1.1 shall not be required where ESFR or large drop sprinkler systems that are approved for rubber tire storage are installed.

12.4.1.4 The rate of water supply shall be sufficient to provide the required sprinkler discharge density over the required area of application plus provision for generation of high-expansion foam and in-rack sprinklers where used.

12.4.1.5 Total water supplies shall be in accordance with the following options:

(1) A minimum of not less than 750 gpm (2835 L/min) for hose streams in addition to that required for automatic sprinklers and foam systems. Water supplies shall be capable of supplying the demand for sprinkler systems and hose streams for not less than 3 hours.
(2) For on-floor storage up to and including 5 ft (1.5 m) in height, hose stream requirements shall be permitted to be 250 gpm (946 L/min) with a water supply duration of not less than 2 hours.
(3) For ESFR and large drop sprinkler systems approved for rubber tire storage, duration and hose demand shall be in accordance with Table 12.4.2(c) and Table 12.4.2(d).

12.4.1.6 Miscellaneous Tire Storage. Miscellaneous tire storage shall be protected in accordance with 12.1.10.

12.4.2* Ceiling Systems. Sprinkler discharge and area of application shall be in accordance with Table 12.4.2(a) and Table 12.4.2(b) for standard spray sprinklers. Large drop and ESFR sprinklers shall be in accordance with Table 12.4.2(c) and Table 12.4.2(d), respectively.

Table 12.4.2(a) Protection Criteria for Rubber Tire Storage Using Control Mode Density-Area Sprinklers

Piling Method	Piling Height (ft)	Sprinkler Discharge Density (gpm/ft²) *(see Note 1)*	Areas of Application (ft²) *(see Note 1)*: Ordinary Temperature	Areas of Application (ft²) *(see Note 1)*: High Temperature *(see Note 1)*
(1) On-floor storage	Up to 5	0.19	2000	2000
(a) Pyramid piles, on-side	Over 5 to 12	0.30	2500	2500
(b) Other arrangements such that no horizontal channels are formed *(see Note 2)*	Over 12 to 18	0.60	Not allowed	2500
(2) On-floor storage	Up to 5	0.19	2000	2000
Tires on-tread	Over 5 to 12	0.30	2500	2500
(3) Palletized portable rack storage	Up to 5	0.19	2000	2000
On-side or on-tread	Over 5 to 20	See Table 12.4.2(b)	—	—
	Over 20 to 30	0.30 plus high-expansion foam	3000	3000
(4) Palletized portable rack storage On-side	Up to 5	0.19	2000	2000
	Over 5 to 20	See Table 12.4.2(b)	—	—
	20 to 25	0.60 and 0.90 *(see Note 3)* or 0.75 with 1-hour fire-resistive rating of roof and ceiling assembly	Not allowed Not allowed Not allowed	5000 3000 4000
(5) Open portable rack storage, on-side or on-tread	Up to 5	0.19	2000	2000
	Over 5 to 12	0.60	5000	3000
	Over 12 to 20	0.60 and 0.90 *(see Note 3)* or 0.30 plus high-expansion foam	Not allowed Not allowed 3000	5000 3000 3000
(6) Single-, double-, and multiple-row fixed rack storage on pallets, on-side or on-tread	Up to 5	0.19	2000	2000
	Over 5 to 20	See Table 12.4.2(b) or 0.40 plus one level in-rack sprinklers or 0.30 plus high-expansion foam	3000 3000	3000 3000
	Over 20 to 30	0.30 plus high-expansion foam	Not allowed	3000
(7) Single-, double-, and multiple-row fixed rack storage without pallets or shelves, on-side or on-tread	Up to 5	0.19	2000	2000
	Over 5 to 12	0.60	5000	3000
	Over 12 to 20	0.60 and 0.90 *(see Note 3)* or 0.40 plus one level in-rack sprinklers or 0.30 plus high-expansion foam	Not allowed Not allowed 3000 3000	5000 3000 3000 3000
	Over 20 to 30	0.30 plus high-expansion foam	Not allowed	3000

For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m²; 1 gpm/ft² = 40.746 mm/min.

Notes:

1. Sprinkler discharge densities and areas of application are based on a maximum clearance of 10 ft (3.1 m) between sprinkler deflectors and the maximum available height of storage. The maximum clearance is noted from actual testing and is not a definitive measurement.
2. Laced tires on-floor, vertical stacking on-side (typical truck tires), and off-road tires. Laced tires are not stored to a significant height by this method due to the damage inflicted on the tire (i.e., bead).
3. Water supply shall fulfill both requirements.

Table 12.4.2(b) Control Mode Density-Area Sprinklers System Density for Palletized Portable Rack Storage and Fixed Rack Storage of Rubber Tires with Pallets, Over 5 ft to 20 ft in Height

	Sprinkler Temperature	
Storage Height	**High Temperature**	**Ordinary Temperature**
>5 ft to 10 ft	0.32/2000	0.32/2000
>10 ft to 12 ft	0.39/2000	0.39/2600
>12 ft to14 ft	0.45/2000	0.45/3200
>14 ft to 16 ft	0.5/2300	0.5/3700
>16 ft to 18 ft	0.55/2600	0.55/4400
>18 ft to 20 ft	0.6/3000	0.6/5000

Table 12.4.2(c) Large Drop Sprinklers and Specific Application Control Mode Sprinkler Protection for Rubber Tires *(see Note 1)*

Piling Method	Pile Height	Number of Sprinklers and Minimum Operating Pressures *(see Note 2)*	Maximum Building Height	Duration (hr)	Hose Demand
Rubber tire storage, on-side or on-tread, in palletized portable racks, or open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	15 sprinklers at 75 psi (5.2 bar) *(see Note 3)*	32 ft (9.8 m)	3	500 gpm (1893 L/min)

Notes:
1. Wet systems only.
2. Sprinkler operating pressures and number of sprinklers in the design are based on tests in which the clearance was 5 ft to 7 ft (1.5 m to 2.1 m) between the sprinkler deflector and the maximum height of storage.
3. The design area shall consist of the most hydraulically demanding area of 15 sprinklers, consisting of five sprinklers on each of three branch lines. The design shall include a minimum operating area of 1200 ft^2 (112 m^2) and a maximum operating area of 1500 ft^2 (139 m^2) and shall utilize a high temperature–rated sprinkler.

Table 12.4.2(d) Early Suppression Fast-Response (ESFR) Sprinklers for Protection of Rubber Tires *(see Note 1)*

Piling Method	Pile Height	Maximum Building Height ft	Maximum Building Height m	Nominal K-factor	Orientation	Number of Sprinklers *(see Note 2)*	Minimum Operating Pressure *(see Note 2)* psi	Minimum Operating Pressure *(see Note 2)* bar	Duration (hours)	Hose Demand gpm	Hose Demand L/min
Rubber tire storage, on-side or on-tread, in palletized portable racks, open portable racks, or fixed racks without solid shelves	Up to 25 ft (7.6 m)	30	9.1	14.0	Upright or pendent	12 *(see Note 3)*	50	3.5	1	250	946
				16.8	Pendent	12 *(see Note 3)*	35	2.4	1	250	946
				25.2	Pendent	12 *(see Note 3)*	15	1.0	1	250	946
Rubber tire storage, on-side, in palletized portable racks, open portable racks, or fixed racks without solid shelves	Up to 25 ft(7.6 m)	35	10.7	14.0	Upright or pendent	12 *(see Note 3)*	75	5.2	1	250	946
				16.8	Pendent	12 *(see Note 3)*	52	3.6	1	250	946
				25.2	Pendent	12 *(see Note 3)*	25	1.7	1	250	946
Laced tires in open portable steel racks	Up to 25 ft(7.6 m)	30	9.1	14.0	Pendent	20 *(see Notes 4 and 5)*	75	5.2	3	500	1892
Rubber tire storage, on-side, in palletized portable racks	Up to 25 ft(7.6 m)	40	12.2	14.0	Pendent	12	75	5.2	1	250	946

Notes:
1. Wet systems only.
2. Sprinkler operating pressures and number of sprinklers in the design are based on tests in which the clearance was 5 ft to 7 ft (1.5 m to 2.1 m) between the sprinkler deflector and the maximum height of storage.
3. The shape of the design area shall be in accordance with 12.2.2.3.3 and 12.2.2.3.4.
4. Where used in this application, ESFR protection is expected to control rather than to suppress the fire.
5. The design area shall consist of the most hydraulically demanding area of 20 sprinklers, consisting of five sprinklers on each of four branch lines. The design shall include a minimum operating area of 1600 ft^2 (149 m^2).

12.4.3 In-Rack Sprinkler System Requirements for Protection of Rubber Tires.

12.4.3.1 In-rack sprinklers, where provided, shall be installed in accordance with Section 12.3, except as modified by 12.4.3.2 through 12.4.3.4.

12.4.3.2 The maximum horizontal spacing of sprinklers in rack shall be 8 ft (2.4 m).

12.4.3.3 Water demand for sprinklers installed in racks shall be based on simultaneous operation of the most hydraulically remote 12 sprinklers where only one level is installed in racks.

12.4.3.4 Sprinklers in racks shall discharge at not less than 30 psi (2.1 bar).

12.4.4 Where high-expansion foam systems are installed in accordance with NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems,* a reduction in sprinkler discharge density to one-half the density specified in Table 12.4.2(a) or 0.24 gpm/ft^2 (9.78 mm/min), whichever is higher, shall be permitted.

12.5 Protection of Baled Cotton Storage.

12.5.1 General.

12.5.1.1 The total water supply available shall be sufficient to provide the recommended sprinkler discharge density over the area to be protected, plus a minimum of 500 gpm (1893 L/min) for hose streams.

12.5.1.2 Water supplies shall be capable of supplying the total demand for sprinklers and hose streams for not less than 2 hours.

12.5.2 Control Mode Density-Area Sprinkler Protection Criteria for Baled Cotton Storage.

12.5.2.1 For tiered or rack storage up to a nominal 15 ft (4.6 m) in height, sprinkler discharge densities and areas of application shall be in accordance with Table 12.5.2.1.

Table 12.5.2.1 Baled Cotton Storage Up to and Including 15 ft (4.6 m)

	Baled Cotton Storage Up to and Including 15 ft		
System Type	**Tiered Storage**	**Rack Storage**	**Untiered Storage**
Wet	0.25/3000	0.33/3000	0.15/3000
Dry	0.25/3900	0.33/3900	0.15/3900

12.5.2.2 Where roof or ceiling heights would prohibit storage above a nominal 10 ft (3.1 m), the sprinkler discharge density shall be permitted to be reduced by 20 percent of that indicated in Table 12.5.2.1 but shall not be reduced to less than 0.15 gpm/ft^2 (6.1 mm/min).

12.6* Protection of Roll Paper Storage.

12.6.1 General.

12.6.1.1 The water supply system for automatic fire protection systems shall be designed for a minimum duration of 2 hours.

12.6.1.1.1 For ESFR sprinklers, the water supply duration shall be 1 hour.

12.6.1.2 At least 500 gpm (1893 L/min) shall be added to the sprinkler demand for large and small hose stream demand.

12.6.1.2.1 For ESFR sprinklers, the hose stream allowance shall be for 250 gpm (947 L/min).

12.6.1.3 The water supply design shall include the demand of the automatic sprinkler system plus the hose stream demand plus, where provided, the high-expansion foam system.

12.6.1.4 Wet pipe systems shall be used in tissue storage areas.

12.6.1.5 Horizontal storage of heavyweight or mediumweight paper shall be protected as a closed array.

12.6.1.6 Mediumweight paper shall be permitted to be protected as heavyweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands. Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg) or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

12.6.1.7 Lightweight paper or tissue paper shall be permitted to be protected as mediumweight paper where wrapped completely on the sides and both ends, or where wrapped on the sides only with steel bands. Wrapping material shall be either a single layer of heavyweight paper with a basis weight of 40 lb (18.1 kg) or two layers of heavyweight paper with a basis weight of less than 40 lb (18.1 kg).

12.6.1.8 For purposes of sprinkler system design criteria, lightweight class paper shall be protected as tissue.

12.6.2* Protection Criteria for the Protection of Roll Paper Storage.

12.6.2.1 Control Mode Density-Area Sprinkler Protection Criteria for the Protection of Roll Paper Storage.

12.6.2.1.1 Storage of heavyweight or mediumweight classes of rolled paper up to 10 ft (3.1 m) in height shall be protected by sprinklers designed for ordinary hazard Group 2 densities.

12.6.2.1.2 Storage of tissue and lightweight classes of paper up to 10 ft (3.1 m) in height shall be protected by sprinklers in accordance with extra hazard Group 1 densities.

12.6.2.1.3 Sprinkler design criteria for storage of roll paper 10 ft (3.1 m) high and higher in buildings or structures with roof or ceilings up to 30 ft (9.1 m) shall be in accordance with Table 12.6.2.1.3(a) and Table 12.6.2.1.3(b).

12.6.2.1.4* High-temperature sprinklers shall be used for installations protecting roll paper stored 15 ft (4.6 m) or higher.

12.6.2.1.5 The protection area per sprinkler shall not exceed 100 ft^2 (9.3 m^2) or be less than 70 ft^2 (6.5 m^2).

12.6.2.1.6 Where high-expansion foam systems are installed in heavyweight class and mediumweight class storage areas, sprinkler discharge design densities can be reduced to not less than 0.24 gpm/ft^2 (9.8 mm/min) with a minimum operating area of 2000 ft^2 (186 m^2).

12.6.2.1.7 Where high-expansion foam systems are installed in tissue storage areas, sprinkler discharge densities and areas of application shall not be reduced below those provided in Table 12.6.2.1.3(a) and Table 12.6.2.1.3(b).

Table 12.6.2.1.3(a) Control Mode Density-Area Sprinkler Protection Criteria for the Protection of Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 30 ft (Discharge Densities are gpm/ft^2 over ft^2)

		Heavyweight					Mediumweight				
		Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array	
Storage Height (ft)	Clearance (ft)	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded or Unbanded	Tissue All Storage Array
10	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2000
10	>5	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.3/2000	0.45/2500
15	≤5	0.3/2000	0.3/2000	0.3/2000	0.3/2500	0.3/3000	0.3/2000	0.3/2000	0.45/2500	0.45/2500	0.60/2000
15	>5	0.3/2000	0.3/2000	0.3/2000	0.3/3000	0.3/3500	0.3/2000	0.3/2500	0.45/3000	0.45/3000	0.60/3000
20	≤5	0.3/2000	0.3/2000	0.3/2500	0.45/3000	0.45/3500	0.3/2000	0.45/2500	0.6/2500	0.6/2500	0.75/2500
20	>5	0.3/2000	0.3/2500	0.3/3000	0.45/3500	0.45/4000	0.3/2500	0.45/3000	0.6/3000	0.6/3000	0.75/3000
25	≤5	0.45/2500	0.45/3000	0.45/3500	0.6/2500	0.6/3000	0.45/3000	0.6/3000	0.75/2500	0.75/2500	*see Note 1*

Notes:
1. Sprinkler protection requirements for tissue stored above 20 ft have not been determined.
2. Densities or areas, or both, shall be permitted to be interpolated between any 5-ft storage height increment.

Table 12.6.2.1.3(b) Control Mode Density-Area Sprinkler Protection Criteria for the Protection of Roll Paper Storage for Buildings or Structures with Roof or Ceilings Up to 9.1 m (Discharge Densities are mm/min over m^2)

		Heavyweight					Mediumweight				
		Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array	
Storage Height (m)	Clearance (m)	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded or Unbanded	Tissue All Storage Arrays
3.1	≤1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	18.3/185.8
3.1	>1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	12.2/185.8	18.3/232.3
4.6	≤1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/232.3	12.2/278.7	12.2/185.8	12.2/185.8	18.3/232.3	18.3/232.3	24.5/185.8
4.6	>1.5	12.2/185.8	12.2/185.8	12.2/185.8	12.2/278.7	12.2/322.2	12.2/185.8	12.2/232.3	18.3/278.7	18.3/278.7	24.5/278.7
6.1	≤1.5	12.2/185.8	12.2/185.8	12.2/232.3	18.3/278.7	18.3/325.2	12.2/185.8	18.3/232.3	24.5/232.3	24.5/232.3	30.6/232.3
6.1	>1.5	12.2/185.8	12.2/232.3	12.2/278.7	18.3/325.2	18.3/371.6	12.2/232.3	18.3/278.7	24.5/278.7	24.5/278.7	30.6/278.7
7.6	≤1.5	18.3/232.3	18.3/278.7	18.3/325.2	24.5/232.3	24.5/278.7	18.3/278.7	24.5/278.7	30.6/232.3	30.6/232.3	*see Note 1*

Notes:
1. Sprinkler protection requirements for tissue stored above 6.1 m have not been determined.
2. Densities or areas, or both, shall be permitted to be interpolated between any 1.5-m storage height increment.

12.6.2.2 Large Drop Sprinklers and Specific Application Control Mode Sprinklers for the Protection of Roll Paper Storage. Where automatic sprinkler system protection utilizes large drop sprinklers, hydraulic design criteria shall be as specified in Table 12.6.2.2. Design discharge pressure shall be 50 psi (3.4 bar). The number of sprinklers to be calculated is indicated based on storage height, clearance, and system type.

12.6.2.3 Early Suppression Fast-Response (ESFR) Sprinklers for the Protection of Roll Paper Storage. Where automatic sprinkler system protection utilizes ESFR sprinklers, hydraulic design criteria shall be as specified in Table 12.6.2.3. Design discharge pressure shall be applied to 12 operating sprinklers.

12.7 Special Designs.

12.7.1* Plastic Motor Vehicle Components. Plastic automotive components and associated packaging material shall be permitted to be protected in accordance with Table 12.7.1.

12.7.2* Sprinkler Design Criteria for Storage and Display of Class I through Class IV Commodities, Cartoned Non-Expanded Group A Plastics, and Non-Expanded Exposed Group A Plastics in Retail Stores.

12.7.2.1 A wet pipe system designed to meet two separate design points — 0.6 gpm/ft^2 density over 2000 ft^2 and 0.7 gpm/ft^2 density for the four hydraulically most demanding sprinklers — shall be permitted to protect single- and double-row slatted shelf racks when the following conditions are met:

(1) An extended coverage sprinkler with a nominal K-factor of 25.2 listed for storage occupancies shall be provided.
(2) Shelves shall be slatted using a 2-in. thick by maximum 6-in. wide slat held in place by spacers that maintain a minimum 2-in. opening between each slat.
(3) There shall be no slatted shelf levels in the rack above nominal 12-ft level. Wire mesh (greater than 50 percent opening) shall be permitted for shelf levels above 12 ft.

Table 12.6.2.2 Large Drop Sprinklers for the Protection of Roll Paper Storage (Number of Sprinklers to be Calculated)

Storage Height		Clearance			Heavyweight					Mediumweight					Tissue All Storage Arrays
					Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array		
ft	m	ft	m	System Type	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	
20	6.1	<10	<3.1	W	15	15	15	15	NA	15	15	15	NA	NA	See Note 3
20	6.1	<10	<3.1	D	25	25	25	NA	NA	25	25	25	NA	NA	NA
26	7.9	<34	<10.4	W	15	15	15	15	NA	NA	NA	NA	NA	NA	NA
26	7.9	<34	<10.4	D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
1. W = wet; D = dry; NA = not applicable.
2. For definition of storage height, see 3.9.2.
3.Twenty-five large drop srpinklers @ 75 psi (5.2 bar) for closed or standard array; other arrays NA.

Table 12.6.2.3 ESFR Sprinklers for the Protection of Roll Paper Storage (Maximum Height of Storage Permitted)

ESFR K-Factor	Orientation	System Type	Pressure		Building Height		Heavyweight						Mediumweight						Tissue All Arrays
							Closed		Standard		Open		Closed		Standard		Open		
			psi	bar	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	ft	m	
11.2	Upright	Wet	50	3.4	25	7.6	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	20	6.1	NA
14.0	Upright or pendent	Wet	50	3.4	30	9.1	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	NA
14.0	Pendent	Wet	75	5.2	40	12.2	30	9.1	30	9.1	30	9.1	NA		NA		NA		NA
25.2	Pendent	Wet	15	1.0	30	9.1	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	25	7.6	NA
25.2	Pendent	Wet	25	1.7	40	12.2	30	9.1	30	9.1	30	9.1	NA		NA		NA		NA
25.2	Pendent	Wet	50	3.4	45	13.7	30	9.1	30	9.1	30	9.1	NA		NA		NA		NA

(4) Solid plywood shelving (3½ ft × 8 ft 3 in.) shall be permissible over the wood slats at the 5-ft level.
(5) Perforated metal (open area of 40 percent or more) shall be permitted over the slatted shelves up to the 60-in. level.
(6) Other than what is allowed in this section, solid plywood or similar materials shall not be placed on the slatted shelves.
(7) Solid veneered particleboard displays shall be permissible provided that all flues are maintained and only one display is installed per bay.
(8) Maximum roof height shall be 30 ft in the protected area.
(9) Maximum storage height shall be 22 ft.
(10) Aisle widths shall be a minimum of 8 ft.
(11) Minimum transverse flue spaces of 3 in. every 10 ft horizontally shall be provided.
(12) Minimum longitudinal flue spaces of 6 in. shall be provided for double-row racks.
(13) Storage in the aisle shall be permissible provided the aisle storage is no more than 4 ft high and a minimum clear aisle of 4 ft is maintained.

12.7.2.2 A wet pipe system designed to meet two separate design points — 0.425 gpm/ft^2 density over 2000 ft^2 and 0.50 gpm/ft^2 density for the four hydraulically most demanding sprinklers — shall be permitted in solid steel cantilever style

Table 12.7.1 K-25.2 ESFR Sprinkler Design Criteria for Portable Racks (Closed Array[1]) without Solid Shelves Containing Automotive Components

Commodity	Maximum Storage Height		Maximum Ceiling/Roof Height		Type of System	Maximum Sprinkler Spacing[2]		Number of Design Sprinklers by Minimum Operating Pressure[3]		Maximum Deflector Distance Below Ceiling[4]		Hose Stream Demand		Water Supply Duration (hours)
	ft	m	ft	m		ft^2	m^2	psi	bar	in.	mm	gpm	L/min	
Automotive components and associated packaging material	25	7.6	35	10.7	Wet	100	9.3	16 at 37 psi	16 at 2.5 bar	18	457	500	1900	2

[1]Portable rack array shall be tightly nested without any flue spaces.
[2]Sprinkler spacing can exceed 100 ft^2 (9.3 m^2) where sprinklers are listed for larger spacing.
[3]System hydraulic design shall also be capable of delivering a discharge density of 0.60 gpm/ft^2 over the most hydraulically remote 4000 ft^2 area.
[4]Maximum deflector distance below ceiling shall be permitted to exceed 18 in.[2] where sprinklers are listed for greater distances.

retail shelving racks (gondola racks) when the following conditions are met:

(1) An extended coverage sprinkler with a nominal K-factor of 25.2 listed for storage occupancies shall be provided.
(2) The storage height shall not exceed 12 ft.
(3) The ceiling height shall not exceed 22 ft in the protected area.
(4) Gondola rack structure shall not exceed 48 in. in aggregate depth or 78 in. in height.
(5) A minimum aisle of 5 ft between storage shall be maintained.
(6) Rack lengths shall be no more than 70 ft.

12.7.2.3 A wet system designed to meet two separate design points — 0.425 gpm/ft^2 density over 2000 ft^2 and 0.50 gpm/ft^2 density for the four hydraulically most demanding sprinklers — shall be permitted in solid steel cantilever-style retail shelving racks (gondola racks) when the following conditions are met:

(1) An extended coverage sprinkler with a nominal K-factor of 25.2 listed for storage occupancies shall be provided.
(2) Storage height shall not exceed 15 ft.
(3) Ceiling height shall not exceed 25 ft in the protected area.
(4) Gondola rack structure shall not exceed 60 in. in aggregate depth or 8 ft in height.
(5) A perforated metal deck at the 8-ft level shall be permissible with storage placed on top with or without flue spaces to a maximum height from floor of 15 ft.
(6) Rack lengths shall not exceed 70 ft.
(7) A minimum aisle space of 6 ft shall be provided.

12.7.2.4 A wet pipe system designed to meet two separate design points — 0.45 gpm/ft^2density over 2000 ft^2 and 0.55 gpm/ft^2 density for the four hydraulically most demanding sprinklers — shall be permitted without the use of in-rack sprinklers when the following are met:

(1) An extended coverage sprinkler with a nominal K-factor of 25.2 listed for storage occupancies shall be provided.
(2) Storage height shall not exceed 15 ft.
(3) Ceiling height shall not exceed 20 ft 6 in.
(4) Shelving structure shall not exceed 48-in. aggregate depth or 12 ft in height.
(5) Shelving shall be permitted to be made of solid particleboard.
(6) A minimum aisle space of 3 ft shall be maintained.
(7) Rack length shall be a maximum of 70 ft.

12.7.2.5 A wet pipe system designed to meet two separate design points — 0.38 gpm/ft^2 density over 2000 ft^2 and 0.45 gpm/ft^2 density for the four hydraulically most demanding sprinklers — shall be permitted without the use of in-rack sprinklers in steel retail sales floor shelving racks where the following are met:

(1) An extended coverage sprinkler with a nominal K-factor of 25.2 listed for storage occupancies shall be provided.
(2) Storage height shall not exceed 14 ft.
(3) Ceiling height shall not exceed 20 ft.
(4) Solid metal shelving shall be permissible up to the 72-in. level and wire shelving shall be permissible up to the 10-ft level.
(5) The solid metal shelving shall not exceed 66 in. in aggregate depth with a 6-in. longitudinal flue between two 30-in. deep shelves.
(6) A minimum aisle space of 5 ft shall be maintained.
(7) A minimum longitudinal flue of 6 in. shall be maintained.
(8) Rack length shall be a maximum of 70 ft.

12.7.2.6 A wet pipe system designed to meet two separate design points — 0.49 gpm/ft^2 density over 2000 ft^2 and 0.55 gpm/ft^2 density for the four hydraulically most demanding sprinklers — shall be permitted without the use of in-rack sprinklers in retail solid shelved steel rack structure when the following are met:

(1) An extended coverage sprinkler with a nominal K-factor of 25.2 listed for storage occupancies shall be provided.
(2) Storage height shall not exceed 16.5 ft.
(3) Ceiling height shall not exceed 22 ft.
(4) Shelving structure shall not exceed 51 in. aggregate depth or 148 in. in height.
(5) The intersection of perpendicular steel racks shall be permissible as long as no storage is placed within the void space at the junction of the racks.
(6) The top shelf shall be wire mesh.
(7) A minimum aisle width of 4 ft shall be maintained between shelf units and other displays.

Chapter 13 Special Occupancy Requirements

13.1 General.

13.1.1 Application.

13.1.1.1 In addition to the requirements of Chapters 8, 11, 12, and 14, the following special occupancy requirements shall apply.

13.1.1.2 Where the requirements of the reference standard differ from the requirements of this standard, the reference standard shall take precedence.

13.1.2 Definitions. For terms not defined in Chapter 3, the definitions of the reference standard shall apply.

13.2 Flammable and Combustible Liquids.

13.2.1 Design Requirements. Sprinkler system discharge criteria for the protection of flammable and combustible liquids shall comply with NFPA 30, *Flammable and Combustible Liquids Code.*

13.2.2 Installation Requirements. (Reserved)

13.3 Aerosol Products.

13.3.1 Design Requirements. Sprinkler system discharge criteria for the protection of aerosol products shall comply with NFPA 30B, *Code for the Manufacture and Storage of Aerosol Products.*

13.3.2 Installation Requirements. (Reserved)

13.4 Spray Application Using Flammable and Combustible Materials.

13.4.1 Design Requirements.

13.4.1.1* Automatic sprinkler systems in spray areas and mixing areas shall be designed for Extra Hazard (Group 2) occupancies. [**33:**7.2.1]

Exception: As provided for in 13.4.1.4. [33:7.2.1]

13.4.1.2 The automatic sprinkler system shall be a wet pipe system where practical. Spray operations that require an open-head deluge system, a combination open- and closed-head automatic sprinkler system, a foam-water sprinkler system, or any other type of extinguishing system (dry chemical or gaseous agent) shall be so protected, subject to the approval of the authority having jurisdiction. [**33:**7.2.2]

13.4.1.3 Water supply for sprinklers shall be sufficient to supply all sprinklers likely to open in any one fire incident without depleting the available water for use in hose streams. Where sprinklers are installed to protect spray areas and mixing rooms only, water shall be permitted to be furnished from the domestic supply, subject to the approval of the authority having jurisdiction and provided the domestic supply can meet the design criteria for extra hazard, Group 2 occupancies. [**33:**7.2.3]

13.4.1.4 Resin application areas shall be protected by an automatic sprinkler system that is designed for at least Ordinary Hazard (Group 2) occupancies. [**33:**15.3]

13.4.2 Installation Requirements.

13.4.2.1* The sprinklers for each spray area and mixing room shall be controlled by a separate, accessible, listed indicating valve. Sprinkler systems in stacks or ducts shall be automatic and of a type not subject to freezing. [**33:**7.2.4]

13.4.2.2 Sprinklers protecting spray areas and mixing rooms shall be protected against overspray residue so that they will operate quickly in event of fire. If covered, cellophane bags having a thickness of 0.003 in. (0.076 mm) or less, or thin paper bags shall be used. Coverings shall be replaced frequently so that heavy deposits of residue do not accumulate. Sprinklers that have been painted or coated, except by the sprinkler manufacturer, shall be replaced with new listed sprinklers having the same characteristics. [**33:**7.2.5]

13.5 Solvent Extraction Plants.

13.5.1* Design Requirements.

13.5.2 Installation Requirements. (Reserved)

13.6 Nitrate Film.

13.6.1 Design Requirements.

13.6.1.1 Rooms where nitrate film is stored or handled in quantities greater than 50 lb [23 kg (10 standard rolls)] shall be protected with an automatic sprinkler system that is designed for extra hazard occupancies.

*Exception: Motion picture projection booths or rooms and rewinding rooms. [**40:**3.1.2]*

13.6.1.2 Water supplies for automatic sprinklers shall be based on 20 gpm (1.26 L/sec) per sprinkler for 20 minutes for the total number of sprinklers in one vault, plus 25 percent of the sprinklers in the communicating fire area. [**40:**3.2.2]

13.6.2 Installation Requirements.

13.6.2.1 In areas or rooms where nitrate film is handled, the area that is protected per sprinkler shall not exceed 64 ft^2 (6 m^2) with sprinklers and branch lines not being over 8 ft (2.4 m) apart. [**40:**3.1.4]

13.6.2.2 Cabinet Protection. [**40:**4.2.5]

13.6.2.2.1 Where cabinets are required to be sprinklered, they shall be provided with at least one automatic sprinkler. [**40:**4.2.5.1]

13.6.2.2.2 Where cans are stored on more than one shelf, as shown in Figure 13.6.2.2.2 and as described in 4.2.6.1 or 4.2.6.2 of NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Film,* one sprinkler shall be provided for each shelf. [**40:**4.2.5.2]

13.6.2.3 Vaults Other than Extended Term Storage Vaults. [**40:**4.3] *(See Figure 13.6.2.3.)*

13.6.2.3.1 Sprinkler protection utilizing regular automatic sprinklers or open sprinklers shall be calculated on the basis of one sprinkler for each 62.5 ft^3 (1.8 m^3) of the interior vault volume. [**40:**4.3.6.1]

13.6.2.3.2 The minimum number of sprinklers for a standard 750-ft^3 (21-m^3) vault shall be not less than 12. [**40:**4.3.6.2]

13.6.2.3.3* Sprinklers or nozzles shall be arranged to provide coverage over the tops and fronts of shelves. [**40:**4.3.6.3]

13.6.2.3.4 Where automatic sprinklers are used, barriers made of No. 24 U.S. gauge sheet steel or other acceptable noncombustible material shall be installed between each sprinkler. Barriers shall be fastened rigidly in place and shall extend from the ceiling down to 4 in. (10 cm) below the sprinkler deflectors. [**40:**4.3.6.4]

13.6.2.4 Extended Term Storage Vaults. See Figure 13.6.2.4.

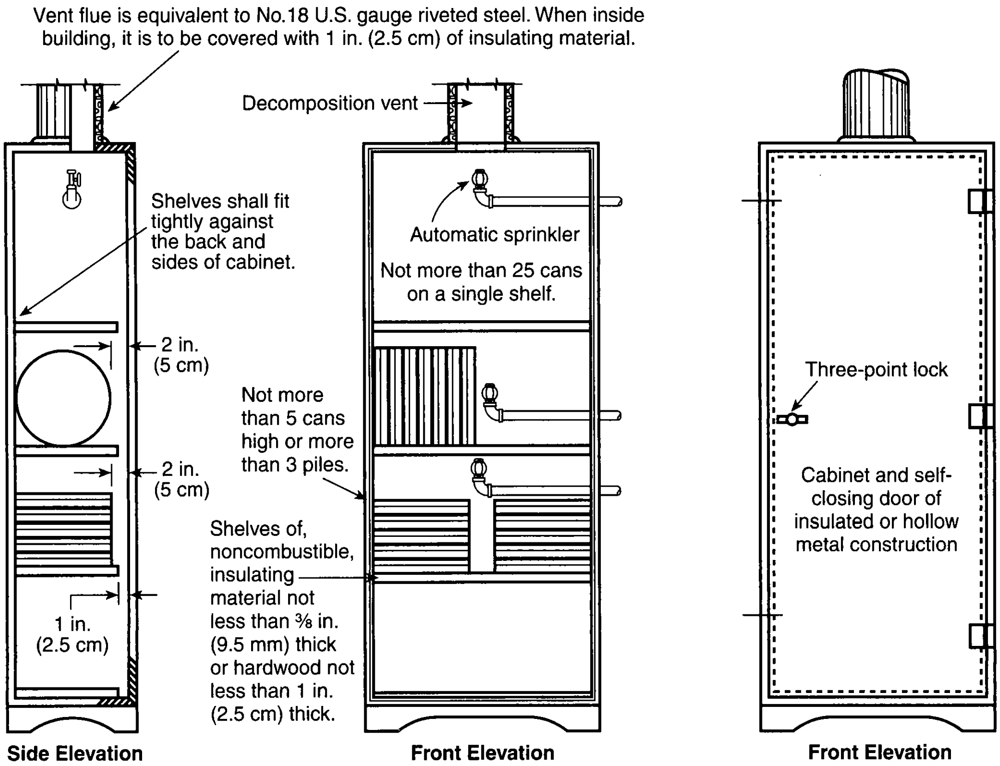


FIGURE 13.6.2.2.2 Standard Film Cabinet for Other than Extended Term Storage Film. [40:Figure 4.2]

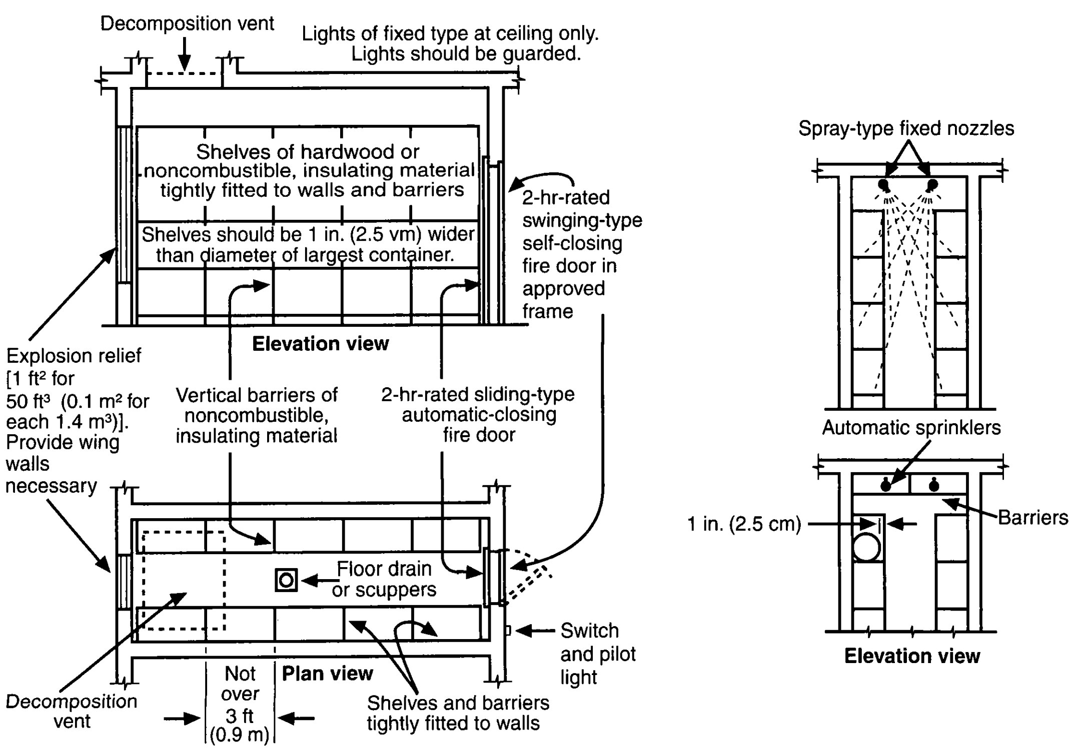


FIGURE 13.6.2.3 Standard Film Vault (for Other than Extended Term Storage Film). [40:Figure 4.3]

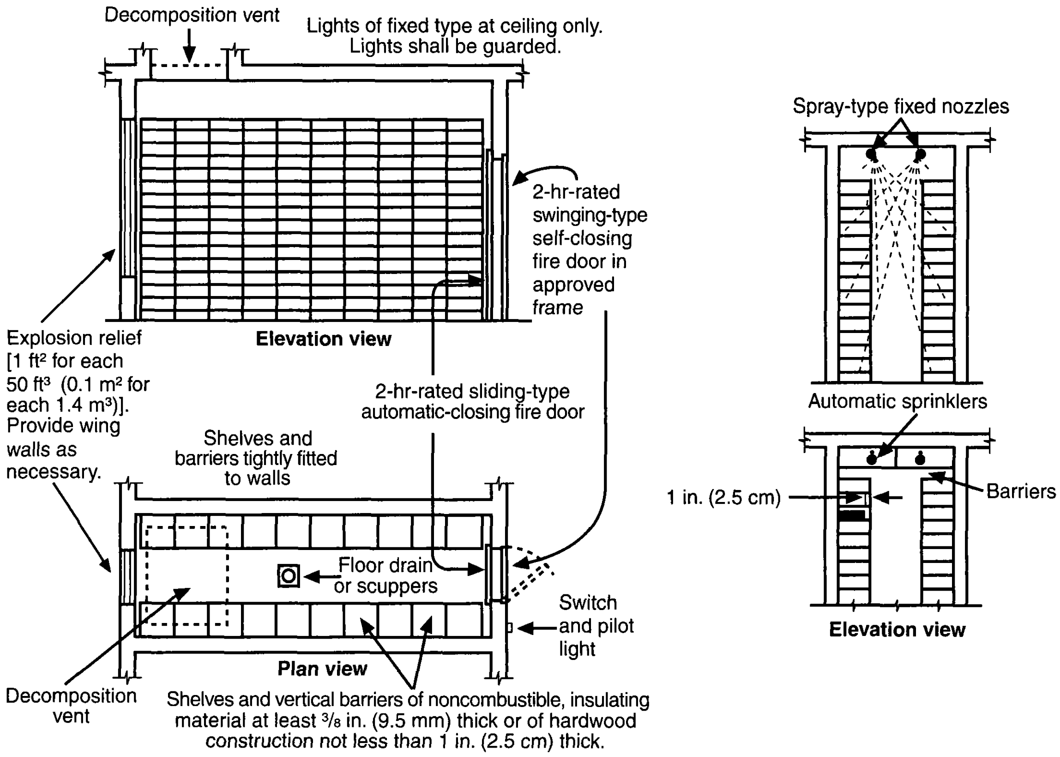


FIGURE 13.6.2.4 Extended Term Storage Vault. [40:Figure 4.5]

13.6.2.4.1 Sprinklers shall be provided in a ratio of one sprinkler for each 62.5 ft^3 (1.8 m^3) of vault volume.

*Exception: Sprinkler systems in existing extended term storage vaults that were in compliance with the provisions of NFPA 40 at the time of installation shall be permitted to be continued in use. [**40:**4.5.5.1]*

13.6.2.4.2 The minimum number of sprinklers for a 1000-ft^3 (28-m^3) vault shall be 15 sprinklers.

*Exception: Sprinkler systems in existing extended term storage vaults that were in compliance with the provisions of NFPA 40 at the time of installation shall be permitted to be continued in use. [**40:**4.5.5.2]*

13.6.2.4.3 Directional sprinklers that will provide coverage into the face of the shelves shall be provided. [**40:**4.5.5.3]

13.6.2.5 Motion Picture Film Laboratories. In all cases, sprinklers shall be arranged so that not more than two machines are protected by any one sprinkler. [**40:**7.2.5.2]

13.7 Storage of Pyroxylin Plastic.

13.7.1 Design Requirements.

13.7.1.1 The water supply for automatic sprinklers shall be based on the number of sprinklers liable to be affected in any fire section between fire walls or fire-resistive partitions. It shall be assumed that any one of the following numbers of sprinklers can be affected and the condition giving maximum flow used as a basis:

(1) All sprinklers in a vault
(2) All sprinklers in a tote box storeroom
(3) Three-fourths of the sprinklers in a finished-stock storeroom
(4) All sprinklers in a section of an isolated storage building [**42:**2.4.3.1]

13.7.1.2 The water supply for an automatic sprinkler system shall be based on a flow of 20 gpm (76 Lpm) per sprinkler for 20 minutes, with a minimum rate of flow of 500 gpm (1900 Lpm). Such flow shall be with an effective pressure at the top line of sprinklers of not less than 40 psi (2.8 bar). [**42:**2.4.3.2]

13.7.2 Installation Requirements. See Figure 13.7.2(a) and Figure 13.7.2(b).

13.7.2.1 Where sprinkler systems are provided for isolated storage buildings per 3.4.3 of NFPA 42, *Code for the Storage of Pyroxylin Plastic*, sprinklers shall be spaced so that there is one sprinkler per 32 ft^2 (3 m^2). [**42:**3.4.3]

13.7.2.2 Sprinklers in buildings used for storage of loose scrap shall be installed in the ratio of one sprinkler for each 1000 lb (454 kg) of storage.

*Exception: The ratio in 13.7.2.2 shall need not apply if the scrap is in tanks or other receptacles kept filled with water. [**42:**3.4.4]*

13.7.2.3 Where cabinets are required to be sprinklered, they shall have at least one automatic sprinkler in each compartment. [**42:**4.2.10]

13.7.2.4 Vaults Containing Pyroxylin Plastic.

13.7.2.4.1 Vaults shall be equipped with automatic sprinklers in a ratio of one sprinkler to each 834 lb (378 kg) of pyroxylin plastic or one sprinkler to each 125 ft^3 (3.5 m^3) of total vault space. [**42:**4.4.1]

13.7.2.4.2 A vault that is divided into two or more sections shall have at least one automatic sprinkler in each section. [**42:**4.4.2]

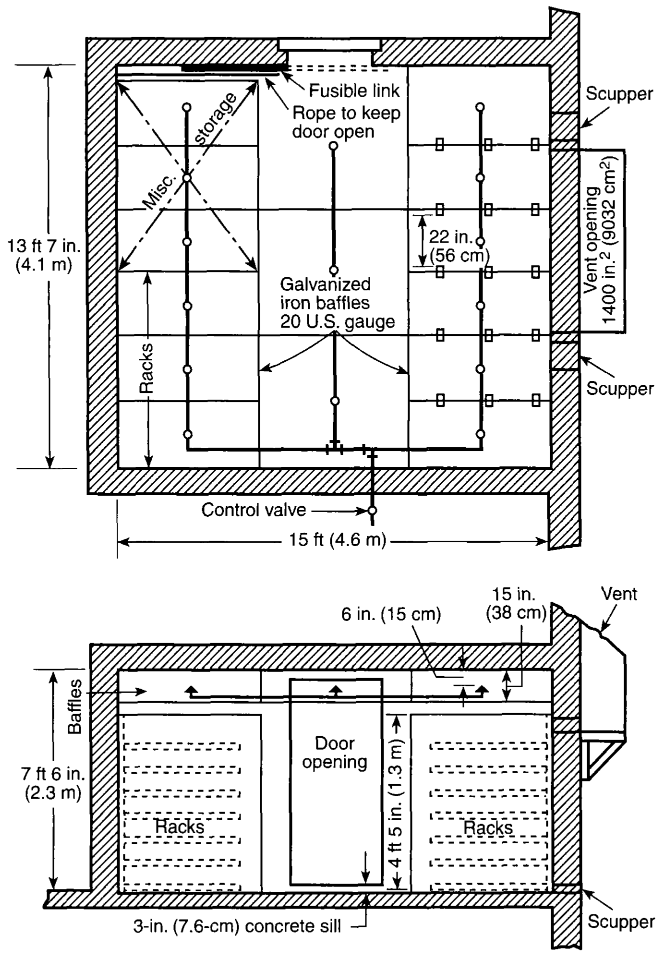


FIGURE 13.7.2(a) Raw Stock Storage Vault Showing General Arrangement of Sprinklers, Racks, and Baffles. [42:Figure 4.3.3.7(a)]

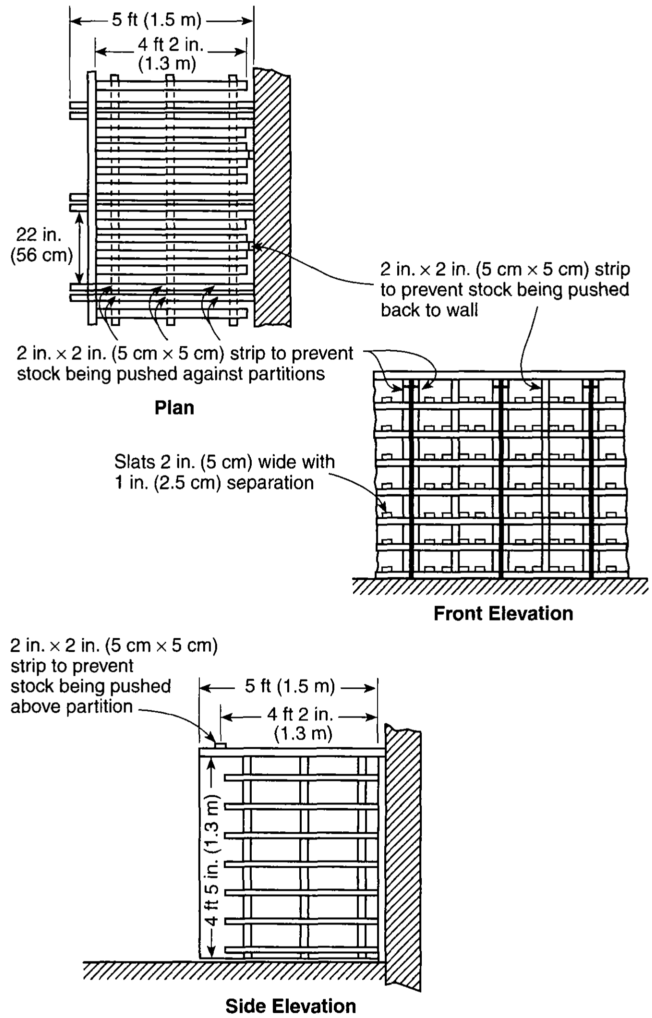


FIGURE 13.7.2(b) Details of Storage Racks in Raw Stock Storage Vault. [42:Figure 4.3.3.7(b)]

13.7.2.4.3 Sprinkler systems for vaults shall be equipped with a 1-in. (2.5-cm) drip line with a ½-in. (13-mm) outlet valve. [**42:**4.4.5]

13.7.2.5 Tote-Box Storeroom for Pyroxylin Plastic. Sprinkler protection provided for the tote box storeroom shall consist of one sprinkler in the center of the aisle immediately in front of the dividing partition between each pair of sections. Proper baffles shall be provided between heads. [**42:**4.7.9] *(See Figure 13.7.2.5(a) and Figure 13.7.2.5(b).)*

13.7.2.6 Finished Stock Storeroom for Pyroxylin Plastic. See Figure 13.7.2.6.

13.7.2.6.1 Automatic sprinklers shall be installed with proper baffles between sprinklers in the center of the aisle opposite each section. [**42:**4.8.7]

13.7.2.6.2 Special Rooms for Stock in Shipping Cases. The special room shall be protected by automatic sprinklers, with at least one sprinkler for each 64 ft^2 (6 m^2). [**42:**4.9.4]

13.8 Laboratories Using Chemicals.

13.8.1 Design Requirements. An automatic sprinkler system, where required by Table 3.1(a) of NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* depending on the construction of the building, the hazard class of the laboratory unit, the construction of the laboratory unit enclosure, and the area of the laboratory unit shall be in accordance with the following:

(1) Automatic sprinkler system protection for Class A and Class B laboratories shall be in accordance with ordinary hazard, Group 2 occupancies.
(2) Automatic sprinkler system protection for Class C and Class D laboratories shall be in accordance with ordinary hazard, Group 1 occupancies. [**45:**4.2.1.1]

13.8.2 Installation Requirements. (Reserved)

13.9 Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes.

13.9.1 Design Requirements. Where sprinkler systems are required per 2.3.1 of NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes,* they shall provide a sprinkler discharge density of at least 0.25 gpm/ft^2 (10.2 mm/min) over a minimum operating area of at least 3000 ft^2 (88 m^2). [**51:**2.3.1, Exception No. 1]

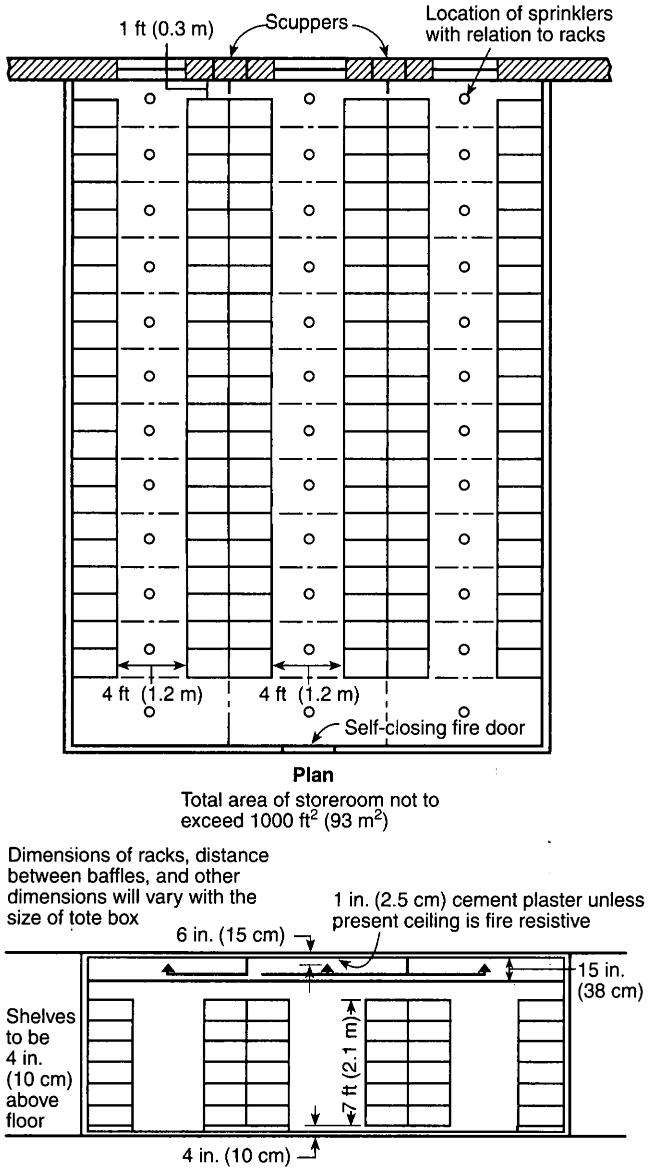


FIGURE 13.7.2.5(a) Tote Box Storeroom Showing General Arrangement of Racks and Sprinklers. [42:Figure 4.7]

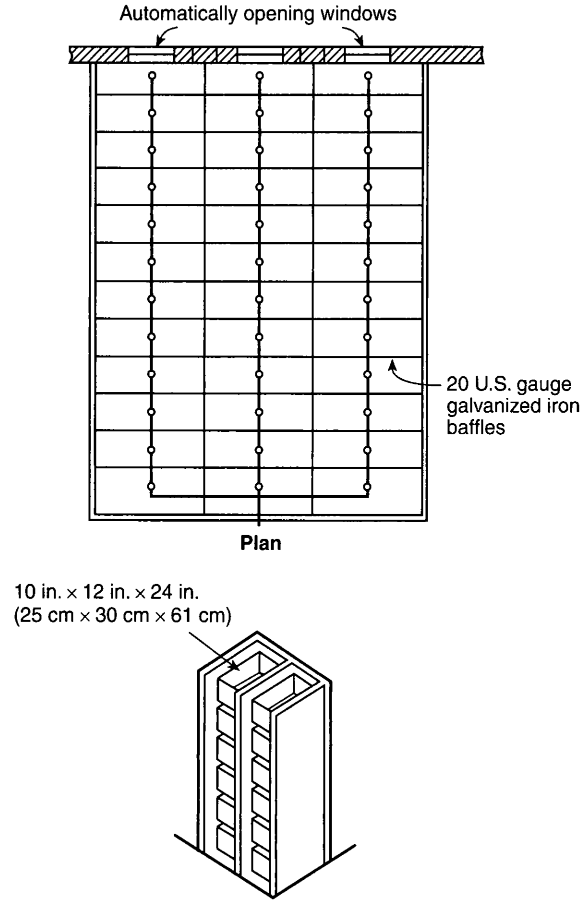


FIGURE 13.7.2.5(b) Tote Box Storeroom Showing Arrangement of Sprinklers and Baffles and Section of Tote Box Storage Rack. [42:Figure 4.7.7]

13.9.2 Installation Requirements. Where sprinkler systems are provided per NFPA 51, 2.3.1, Exception No. 1, sprinklers shall be located not more than 20 ft (6 m) above the floor where the cylinders are stored. [**51**:2.3.1, Exception No. 1]

13.10 Acetylene Cylinder Charging Plants.

13.10.1 Design Requirements. Where an automatic sprinkler system is required per NFPA 51A, *Standard for Acetylene Cylinder Charging Plants*, it shall be an extra hazard (Group 1) open or closed head sprinkler system. [**51A**:9.2.2]

13.10.2 Installation Requirements. (Reserved)

13.11 Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders.

13.11.1 Design Requirements.

13.11.1.1 Where an automatic sprinkler system is required per NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders*, the sprinkler system protecting the gas cylinder storage, and for a distance of 25 ft (7.6 m) beyond in all directions, shall be capable of providing a sprinkler density of at least 0.3 gpm/ft^2 (12.2 mm/min) over the most hydraulically remote 2500 ft^2 (232.25 m^2). [**55**:2.2.2.1]

13.11.1.2 Where sprinkler systems are provided per NFPA 55, 2.2.2.2, Exception No. 1, they shall be designed for ordinary hazard, Group 1 occupancies. [**55**:2.2.2.2]

13.11.1.3 Where sprinkler systems are provided per NFPA 55, 2.2.2.2, Exception No. 2, they shall be designed for ordinary hazard, Group 1 occupancies. [**55**:2.2.2.2]

13.11.1.4 Where sprinkler systems are required for gas cylinder storage rooms per NFPA 55, they shall be capable of providing a minimum density of 0.3 gpm/ft^2 (12.2 mm/min) over the most hydraulically remote 2500 ft^2 (232.25 m^2) or the entire room area, whichever is smaller. [**55**:2.2.3.2]

13.11.2 Installation Requirements. (Reserved)

13.12 Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants.

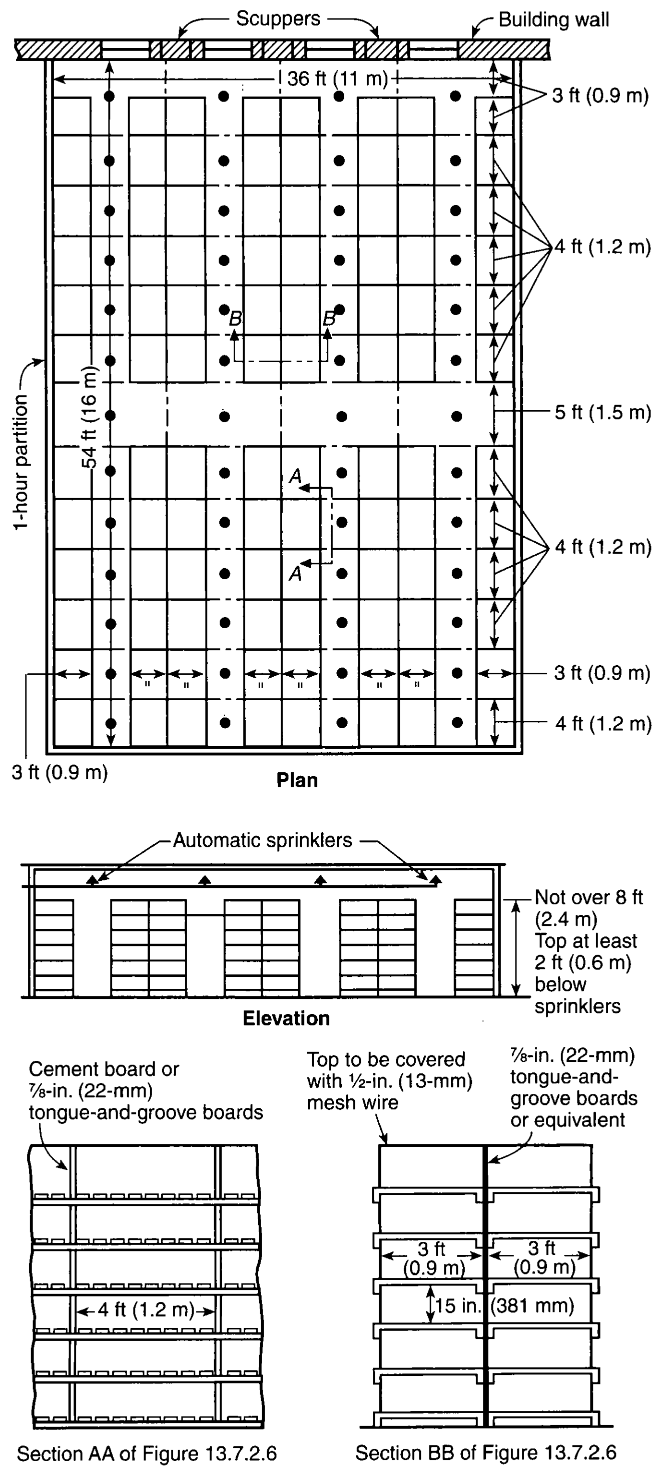


FIGURE 13.7.2.6 Finished-Stock Storeroom Showing General Arrangement of Racks. [42:Figure 4.8]

13.12.1 Design Requirements. The design of fire water supply and distribution systems, if required by NFPA 59, *Utility LP-Gas Plant Code,* shall provide for the simultaneous supply of those fixed fire protection systems, including monitor nozzles, at their design flow and pressure, involved in the maximum single incident expected in the plant. An additional supply of 1000 gpm (3785 L/min) shall be available for hand hose streams for a period of not less than 2 hours. Manually actuated monitors shall be permitted to be used to augment hand hose streams. [**59:**10.5.2]

13.12.2 Installation Requirements. (Reserved)

13.13 Production, Storage, and Handling of Liquefied Natural Gas (LNG).

13.13.1 Design Requirements. The design of fire water supply and distribution systems, if required by NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* shall provide for the simultaneous supply of those fixed fire protection systems, including monitor nozzles, at their design flow and pressure, involved in the maximum single incident expected in the plant plus an allowance of 1000 gpm (3785 L/min) for hand hose streams for not less than 2 hours. [**59A:** 9.5.2]

13.13.2 Installation Requirements. (Reserved)

13.14 Electronic Computer Systems.

13.14.1 Design Requirements. (Reserved)

13.14.2 Installation Requirements. Where sprinkler systems are provided per NFPA 75, *Standard for the Protection of Electronic Computer/Data Processing Equipment,* they shall be valved separately from other sprinkler systems. [**75:**6.1.3]

13.15 Incinerators, Systems, and Equipment.

13.15.1 Design Requirements. (Reserved)

13.15.2 Installation Requirements.

13.15.2.1 Chute Automatic Sprinklers. [**82:**3.2.5]

13.15.2.1.1 Gravity Chute. Gravity chutes shall be protected internally by automatic sprinklers. This requires a sprinkler at or above the top service opening of the chute, and, in addition, a sprinkler shall be installed within the chute at alternate floor levels in buildings over two stories in height with a mandatory sprinkler located at the lowest service level. [**82:**3.2.5.1] *(See Figure 13.15.2.1.1.)*

*Exception No. 1: Lined masonry chute that complies with 3.2.2.5 of NFPA 82. [**82:**3.2.5.1]*

*Exception No. 2: Lined metal chute that complies with 3.2.2.6 of NFPA 82. [**82:**3.2.5.1]*

*Exception No. 3: Listed medium-heat chimney that complies with 3.2.2.8 of NFPA 82, Standard on Incinerators and Waste and Linen Handling Systems and Equipment. [**82:**3.2.5.1]*

13.15.2.1.2 Chute Sprinkler Head Protection. Automatic sprinklers installed in gravity chute service openings shall be recessed out of the chute area through which the material travels. [**82:**3.2.5.2]

13.15.2.2 Automatic Sprinklers, Full Pneumatic Systems. Full pneumatic-type risers shall be protected internally by automatic sprinklers. A sprinkler shall be required at or above the top loading station and at alternate floor levels in buildings over two stories in height, with a mandatory sprinkler located at the lowest loading station. Sprinklers shall be recessed out of the station area through which the material travels. [**82:**3.3.4] *(See Figure 13.15.2.2.)*

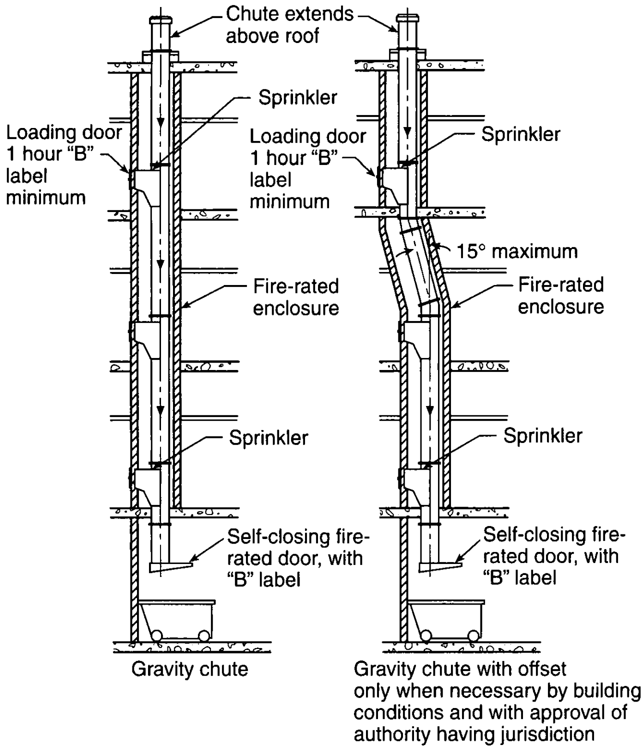


FIGURE 13.15.2.1.1 Gravity Chute. [82:Figure 3.2.5.1]

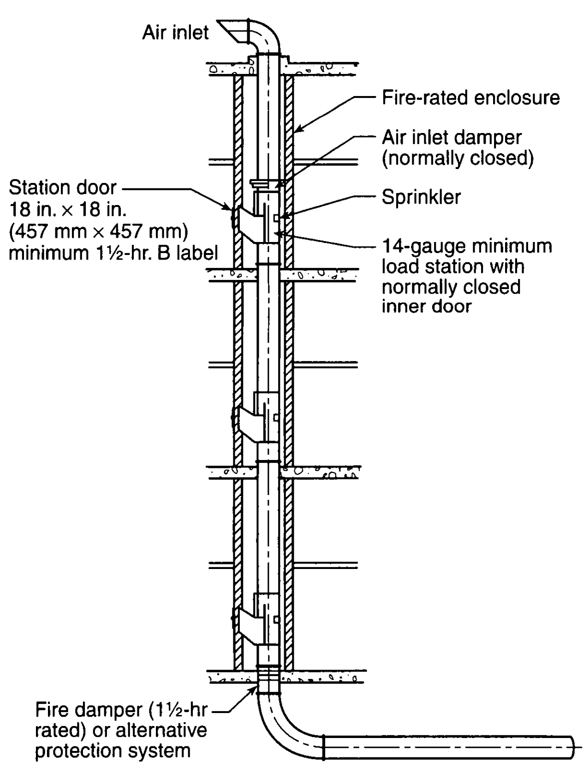


FIGURE 13.15.2.2 Full Pneumatic System. [82:Figure 3.3.4]

13.15.2.3 Commercial-Industrial Compactors. All chute-fed compactors shall have an automatic special fine water spray sprinkler with a minimum ½-in. (13-mm) orifice installed in the hopper of the compactor. This sprinkler shall be an ordinary temperature-rated sprinkler. The sprinklers shall be supplied by a minimum 1-in. (25.4-mm) ferrous piping or ¾-in. (19-mm) copper tubing line from the domestic cold water supply. The sprinkler shall provide a suitable spray into the hopper. A cycling (on-off), self-actuating, snap-action, heat-actuated sprinkler shall be permitted to be used, or the sprinkler shall be permitted to be controlled by a temperature sensor operating a solenoid valve. Sprinkler water piping shall be protected from freezing in outdoor installations. [**82:**5.2.5.2.1]

13.16 Industrial Furnaces Using a Special Process Atmosphere.

13.16.1 Design Requirements. (Reserved)

13.16.2 Installation Requirements. Where sprinkler systems are provided per NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere,* 18.1.2(b), sprinklers shall be of extra high-temperature rating [325°F to 650°F (163°C to 343°C] to avoid premature operation from localized flashing. [**86C:**18.1.2(b)]

13.17 Ventilation Control and Fire Protection of Commercial Cooking Operations.

13.17.1 Design Requirements. (Reserved)

13.17.2 Installation Requirements. (Reserved)

13.18 Class A Hyperbaric Chambers.

13.18.1 Design Requirements.

13.18.1.1 In chambers that consist of more than one chamber compartment (lock), the design of the deluge system shall ensure adequate operation when the chamber compartments are at different depths (pressures). The design shall also ensure the independent or simultaneous operation of deluge systems.

*Exception: Chamber compartments that are used strictly as personnel transfer compartments (locks), and for no other purposes, are not required to have a fixed deluge system. [**99:**19.2.5.2]*

13.18.1.2* Manual activation and deactivation deluge controls shall be located at the operator's console and in each chamber compartment (lock) containing a deluge system. Controls shall be designed to prevent unintended activation. [**99:**19.2.5.2.1]

13.18.1.3 Water shall be delivered from the sprinkler heads as specified in 13.18.1.4 within 3 seconds of activation of any affiliated deluge control. [**99:**19.2.5.2.2]

13.18.1.4* Average spray density at floor level shall be not less than 2 gpm/ft^2 (81.5 L/min/m^2) with no floor area larger than 1 m^2 receiving less than 1 gpm/ft^2 (40.75 L/min/m^2). [**99:**19.2.5.2.3]

13.18.1.5* The number and positioning of sprinklers shall be sufficient to provide reasonably uniform spray coverage with vertical and horizontal (or near horizontal) jets. [**99:**19.2.5.2.3]

13.18.1.6 There shall be sufficient water available in the deluge system to maintain the flow specified in 13.18.1.4 simultaneously in each chamber compartment (lock) containing the deluge system for 1 minute. The limit on maximum extinguishment duration shall be governed by the chamber capacity (bilge capacity also, if so equipped) and/or its drainage system. [**99:**19.2.5.2.4]

13.18.1.7 The deluge system shall have stored pressure to operate for at least 15 seconds without electrical branch power. [**99:**19.2.5.2.5]

13.18.2 Installation Requirements. (Reserved)

13.19 Fixed Guideway Transit Systems.

13.19.1 Design Requirements. In all areas of enclosed structures used for storage and maintenance of vehicles the sprinkler system shall be of a closed-head type for Ordinary Hazard classification. [**130:**6.4.1]

13.19.2 Installation Requirements. (Reserved)

13.20 Race Track Stables.

13.20.1 Design Requirements. Automatic sprinkler systems shall be designed in accordance with Ordinary Hazard Group 2 classification. [**150:**4.1.2]

13.20.2 Installation Requirements. (Reserved)

13.21 Water Cooling Towers.

13.21.1 Design Requirements.

13.21.1.1 Types of Systems.

13.21.1.1.1* Because the counterflow tower design lends itself to either closed- or open-head systems, wet-pipe, dry-pipe, preaction, or deluge systems shall be permitted to be used. [**214:**3.2.2.1]

13.21.1.1.2* The open-head deluge system shall be used in crossflow towers to maximize the water distribution and heat detection activation. [**214:**3.2.2.2]

13.21.1.2 Minimum Rate of Application.

13.21.1.2.1 Under the fan decks of counterflow towers, the rate of application of water shall be 0.5 gpm/ft^2 (20.4 L/min·m^2) (including fan opening). [**214:**3.2.3.1]

13.21.1.2.2 Under the fan decks of crossflow towers, the rate of application of water shall be 0.33 gpm/ft^2 (13.45 L/min·m^2) (including fan opening). [**214:**3.2.3.2]

13.21.1.2.3 Over the fill areas of crossflow towers, the rate of application of water shall be 0.5 gpm/ft^2 (20.4 L/min·m^2). [**214:**3.2.3.3]

13.21.1.3 Extended Fan Decks. On towers having extended fan decks that completely enclose the distribution basin, the discharge outlets protecting the fill area shall be located over the basin, under the extension of the fan deck. These discharge outlets shall be open directional spray nozzles or other approved spray devices arranged to discharge 0.35 gpm/ft^2 (14.26 L/min·m^2) directly on the distribution basin and 0.15 gpm/ft^2 (6.11 L/min·m^2) on the underside of the fan deck extension. On towers having extended fan decks that do not completely enclose the hot water basin, outlets protecting the fill shall be located under the distribution basin as set out in 3.2.4.2. of NFPA 214, *Standard on Water-Cooling Towers.* [**214:**3.2.4.3]

13.21.1.4 Combustible Fan Decks. For deluge systems using directional spray nozzles in the pendent position, provisions shall be made to protect the underside of a combustible fan deck at a minimum of 0.15 gpm/ft^2 (6.11 L/min·m^2), which shall be included as part of the application rate specified in 13.21.1.3. [**214:** 3.2.4.4]

13.21.1.5 Water Basin Covers. On film-filled towers that have solid, hot-water basin covers over the complete basin, the discharge outlets protecting the fill area shall be permitted to be located under the basin covers. These discharge outlets shall be open directional spray nozzles or other approved devices arranged to discharge 0.35 gpm/ft^2 (14.26 L/min·m^2) directly on the distribution basin, and 0.15 gpm/ft^2 (6.11 L/min·m^2) on the underside of the water basin covers. [**214:**3.2.4.5]

13.21.1.6 Exterior Protection. Systems for exterior protection shall be designed with the same attention and care as interior systems. Pipe sizing shall be based on hydraulic calculations. Water supply and discharge rate shall be based on a minimum 0.15 gpm/ft^2 (6.11 L/min·m^2) for all surfaces being protected. [**214:**3.2.10.2]

13.21.1.7 Sprinkler System Water Supply.

13.21.1.7.1 Deluge Systems.

13.21.1.7.1.1* Where all cells of a cooling tower are protected by a single deluge system, the water supply shall be adequate to supply all discharge outlets on that system. [**214:**3.6.1.1]

13.21.1.7.1.2 Where two or more deluge systems are used to protect a cooling tower and fire-resistant partitions are not provided between the deluge systems, the water supply shall be adequate to supply all discharge outlets in the two most hydraulically demanding adjacent systems. [**214:**3.6.1.2]

13.21.1.7.1.3* Where two or more deluge systems are separated by fire-resistant partitions, the water supply shall be adequate to supply all discharge outlets in the single most hydraulically demanding system. [**214:**3.6.1.3]

13.21.1.7.2 Wet, Dry, and Preaction Systems.

13.21.1.7.2.1* Where each cell of the cooling tower is separated by a fire-resistant partition, the water supply shall be adequate to supply all discharge outlets in the hydraulically most demanding single cell. [**214:**3.6.2.1]

13.21.1.7.2.2* Where fire-resistant partitions are not provided between each cell of a cooling tower, the water supply shall be adequate to supply all discharge outlets in the two most hydraulically demanding adjoining cells. [**214:**3.6.2.2]

13.21.1.7.3 Hose Streams. Water supplies shall be sufficient to include a minimum of 500 gpm (1892.5 L/min) for hose streams in addition to the sprinkler requirements. [**214:**3.6.3]

13.21.1.7.4 Duration. An adequate water supply of at least 2-hour duration shall be provided for the combination of the water supply specified in 13.21.1.7.1 or 13.21.1.7.2, plus the hose stream demand specified in 13.21.1.7.3. [**214:**3.6.4]

13.21.2 Installation Requirements.

13.21.2.1* Counterflow Towers. [**214:**3.2.4.1]

13.21.2.1.1 The discharge outlets shall be located under the fan deck and fan opening. [**214:**3.2.4.1.1]

13.21.2.1.2 Except under the fan opening, all discharge outlets shall have deflector distances installed in accordance with Section 8.5. [**214:**3.2.4.1.2]

13.21.2.1.3 Closed-head discharge outlets for dry-pipe and preaction systems shall be installed in the upright position only. [**214:**3.2.4.1.3]

13.21.2.2* Crossflow Towers. [**214:**3.2.4.2]

13.21.2.2.1 The discharge outlets protecting the plenum area shall be located under the fan deck and in the fan opening. [**214:**3.2.4.2.1]

13.21.2.2.2 Discharge outlets protecting the fill shall be located under the distribution basin on either the louver or drift eliminator side, discharging horizontally through the joist channels. [**214:**3.2.4.2.2]

13.21.2.2.3 Towers with a fill area longer than the maximum allowable for the discharge device being used shall have discharge devices placed on both sides of the fill area in each joist channel. The pressure at each discharge device shall be adequate to provide protection for half of the length of the fill area. [**214:**3.2.4.2.3]

13.21.2.2.4 Where joist channels are wider than 2 ft (0.6 m), more than one discharge device shall be required per joist channel.

*Exception: If the discharge device being used is listed for the width of the joist channel being protected. [**214:**3.2.4.2.4]*

13.21.2.3* Extended Fan Decks. On towers having extended fan decks that completely enclose the distribution basin, the discharge outlets protecting the fill area shall be located over the basin, under the extension of the fan deck. [**214:**3.2.4.3]

13.21.2.4 Combustible Fan Decks. For deluge systems using directional spray nozzles in the pendent position, provisions shall be made to protect the underside of a combustible fan deck. [**214:**3.2.4.4]

13.21.2.5* Water Basin Covers. On towers having basin covers that do not completely enclose the hot water basin, outlets protecting the fill shall be located under the distribution basin as set out in 13.21.2.2. [**214:**3.2.4.5]

13.21.2.6 Valves. [**214:**3.2.6]

13.21.2.6.1 General. Shutoff valves and automatically operated water control valves, if provided, shall be located:

(1) Outside the fire-exposed area
(2) As close to the cooling tower as possible to minimize the amount of pipe to the discharge device
(3) Where they will be accessible during a fire emergency [**214:**3.2.6.1]

13.21.2.6.2 Manual Release Valve. Remote manual release valves, where required, shall be conspicuously located and readily accessible during a fire emergency. If remote, manual release valves are not required, an inspector's test valve shall be provided for each pilot-head-operated system. [**214:**3.2.6.2]

13.21.2.7 Strainers. Strainers shall be required for systems utilizing discharge devices with waterways of less than 0.375-in. (9.5-mm) diameter. *(See NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection, for further details.)* [**214:**3.2.7]

13.21.2.8 Heat Detectors. [**214:**3.2.8]

13.21.2.8.1 Where deluge or preaction systems are used, heat detectors shall be installed in accordance with the applicable sections of *NFPA 72, National Fire Alarm Code. [**214:**3.2.8.1]*

13.21.2.8.2 In mechanical induced-draft towers, heat detectors shall be located under the fan deck at the circumference of the fan opening and under the fan opening where necessary to comply with the following spacing requirements. *(For extended fan decks, see 3.2.8.3 in NFPA 214.)* [**214:**3.2.8.2]

13.21.2.8.2.1 Fixed-temperature detectors shall be spaced not more than 8 ft (2.4 m) apart in any direction including the fan opening. Temperature ratings shall be selected in accordance with operating conditions, but shall be no less than intermediate. [**214:**3.2.8.2.1]

13.21.2.8.2.2 Rate-of-rise detectors shall be spaced not more than 15 ft (4.6 m) apart in any direction. In pneumatic-type systems, for detectors inside the tower, there shall be no more than one detector for each mercury check in towers operating in cold climates, and two detectors for each mercury check in towers used during the warm months only or year-round in warm climates. There shall be no more than four detectors for each mercury check where the detectors are located outside the tower. [**214:**3.2.8.2.2]

13.21.2.8.3 On towers having extended fan decks that completely enclose the distribution basin, detectors shall be located under the fan deck extension in accordance with standard, indoor-spacing rules for the type detectors used. *(See NFPA 72, National Fire Alarm Code.)*

*Exception: Where the fan deck extension is 16 ft (4.9 m) or less and this dimension is the length of the joist channel, then only one row of detectors centered on and at right angles to the joist channels shall be required. Spacing between detectors shall be in accordance with NFPA 72, National Fire Alarm Code. On towers having extended fan decks that do not completely enclose the hot water basin, detectors shall not be required under the fan deck extension. [**214:** 3.2.8.3]*

13.21.2.8.4 Where the total number of deluge systems exceeds the number for which the water supply was designed, heat barriers shall be installed under the extended fan deck to separate the systems. Heat barriers shall extend from the fan deck structure to the distribution basin dividers. [**214:**3.2.8.4]

13.21.2.8.5 Where heat detectors are inaccessible during tower operation, an accessible test detector shall be provided for each detection zone. [**214:**3.2.8.5]

13.21.2.8.6 Heat detector components exposed to corrosive vapors or liquids shall be protected by materials of suitable construction or by suitable, protective coatings applied by the equipment manufacturer. [**214:**3.2.8.6]

13.21.2.9 Protection for Fan Drive Motor. [**214:**3.2.9]

13.21.2.9.1 A heat detector and water discharge outlet shall be provided over each fan drive motor when the motor is located so that it is not within the protected area of the tower. [**214:**3.2.9.1]

13.21.2.9.2 Provision shall be made to interlock the fan motors with the fire protection system so that the cooling tower fan motors will be stopped in the cell(s) for which the system is actuated. Where the continued operation of the fans is vital to the process, a manual override switch may be provided to reactivate the fan when it is determined that there is no fire. [**214:**3.2.9.2]

13.21.2.10 Corrosion Protection. [**214:**3.3]

13.21.2.10.1 Piping, fittings, hangers, braces, and attachment hardware including fasteners shall be hot-dip galvanized steel per ASTM A 153, *Standard Specification for Zinc Coating (Hot Dip) on Iron and Steel Hardware,* or other materials having a superior corrosion resistance. Exposed pipe threads and bolts on fittings shall be protected against corrosion. All other components shall be corrosion resistant or protected against corrosion by a suitable coating. [**214:**3.3.1]

13.21.2.10.2* Wax-type coatings shall not be used on devices without fusible elements. [**214**:3.3.2]

13.21.2.10.3* Special care shall be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating. Corrosion-resistant coatings shall not be applied to the sprinklers by anyone other than the manufacturer of the sprinklers, except that in all cases any damage to the protective coating occurring at the time of installation shall be repaired at once using only the coating of the manufacturer of the sprinkler in an approved manner so that no part of the sprinkler will be exposed after the installation has been completed. [**214**:3.3.3]

13.22 Piers, Terminals, and Wharves.

13.22.1 Design Requirements.

13.22.1.1* Piers and Wharves.

13.22.1.1.1 Sprinklers shall be 12.7-mm (½-in.) orifice and shall discharge at a minimum pressure of 85 kPa (12.5 psi). [**307**:3.3.3.1.3(a)5]

13.22.1.1.2 Design area shall be based upon the largest area between firestops plus an additional area embracing at least two branch lines on opposite sides of the fire-stop. [**307**:3.3.3.1.3(a)5b]

13.22.1.1.3 Minimum design area shall be not less than 465 m^2 (5000 ft^2). [**307**:3.3.3.1.3(a)5c]

13.22.1.1.4 The maximum area to be protected by any one system shall be limited to 2325 m^2 (25,000 ft^2). [**307**:3.3.3.1.3(a)7]

13.22.1.2 Terminal Buildings.

13.22.1.2.1 Due to the widely varying nature of commodities that might pass through transit sheds, container freight stations, transload facilities, and similar buildings used for handling and temporary storage of general cargo, minimum sprinkler design shall be based upon Extra Hazard (Group 1) classification. [**307**:4.4.2]

13.22.1.2.2 If the maximum storage height that the building will permit exceeds 3.7 m (12 ft), the requirements shall be followed for the protection of Class I, II, III, IV, or plastic commodities piled to the maximum height permitted by building construction, and the clearance requirements of 8.5.6 of NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves.* [**307**:4.4.3]

13.22.1.2.3 If racks or shelving are present or likely to be present, the requirements shall be followed for the protection of Class I, II, III, IV, or plastic commodities. Protection in warehouses for the long-term storage of specific commodities shall be designed for the specific use unless the buildings exceed 465 m^2 (5000 ft^2) total floor area. [**307**:4.4.4]

13.22.2 Installation Requirements.

13.22.2.1 Where there is danger of damage to sprinkler equipment by floating objects, physical barriers shall be provided to exclude such objects. [**307**:3.3.3.1.2]

13.22.2.2 The following installation criteria shall also apply.

(1) Where narrow horizontal channels or spaces are caused by caps, stringers, ties, and other structural members, the standard upright sprinkler might not project sufficient water upward to extinguish or control fires on the underside of the pier or wharf deck. In these cases, a sprinkler that projects water upward to wet the overhead, such as a pendent sprinkler installed in an upright position, or the old-style sprinkler shall be used. Location, spacing, and deflector position shall be governed by the discharge pattern of the sprinkler and the structure being protected. The following design and installation guides shall apply where pendent sprinklers in the upright position or old-style sprinklers are to be utilized:
    (a) The maximum coverage per sprinkler head shall be limited to 7.5 m^2 (80 ft^2).
    (b) Where spacing or arrangement of stringers constitutes typical open-joist construction directly supporting the deck, sprinkler branch lines shall be installed between the bents at right angles to the stringers. Spacing between branch lines shall not exceed 3 m (10 ft). Sprinklers on branch lines shall be staggered and spaced not to exceed 2.5 m (8 ft) on centers.
    (c) Where crisscross construction (typically ties on stringers — see diagram in Appendix B of NFPA 307) is involved, closer spacing of sprinklers shall be permitted as necessary to provide wetting of the entire structure.
    (d) The deflectors of sprinklers on lines under stringers shall be located not less than 100 mm (4 in.) nor more than 250 mm (10 in.) below the bottom plane of the stringer, and not more than 450 mm (18 in.) below the underside of the pier or wharf deck.
    (e) The temperature rating of the sprinkler shall not exceed 74°C (165°F).
    (f) The maximum area to be protected by any one system shall be limited to 2325 m^2 (25,000 ft^2).
(2) Sprinklers designed and approved specifically for protection of combustible substructures shall be installed in conformity with their listing.
(3) The pipe hangers shall be placed in a location where they will be in the wetting pattern of the sprinkler to prevent the lag screws from burning or charring out, dropping sprinkler piping, and bleeding the system. The distance from the sprinkler to the hanger shall not exceed 460 mm (18 in.).
(4) Horizontal and vertical bracing shall be provided at not more than 6-m (20-ft) intervals on all sprinkler piping 76 mm (3 in.) or larger that is parallel to and within 15 m (50 ft) of the face of the pier or wharf and where it might be subjected to heavy fireboat nozzle streams.
(5) Sprinkler systems, including hanger assemblies and bracing, in underdeck areas shall be properly protected throughout against corrosion. Sprinklers shall be of corrosion-resistant type. When the fire protection design for substructures involves the use of detectors or other electrical equipment for smoke or heat detection, preaction or deluge-type sprinkler protection, all detectors and wiring systems shall be moisture- and corrosion-proof to protect against unfavorable atmospheric conditions that exist beneath these structures. Frequent inspection and testing of these systems shall be conducted in accordance with applicable NFPA standards.
(6) Water supply systems, hydrants, fire hose valves, and sprinkler systems shall be installed with adequate protection against freezing and physical damage.

[**307**:3.3.3.1.3]

13.23 Cleanrooms.

13.23.1 Design Requirements.

13.23.1.1* Automatic sprinklers for cleanrooms or clean zones shall be hydraulically designed for a density of 0.20 gpm/ft^2 (8.15 L/min·m^2) over a design area of 3000 ft^2 (278.8 m^2). [**318**:2.1.2.1]

13.23.1.2 Automatic sprinkler protection shall be designed and installed in the plenum and interstitial space above cleanrooms for a density of 0.20 gpm/ft^2 (8.15 L/min·m^2) over a design area of 3000 ft^2 (278.8 m^2).

Exception: Automatic sprinklers can be omitted if the construction and occupancy of these spaces are noncombustible. [318:2.1.2.6]

13.23.1.3* Sprinklers installed in duct systems shall be hydraulically designed to provide 0.5 gpm (1.9 L/min) over an area derived by multiplying the distance between the sprinklers in a horizontal duct by the width of the duct. Minimum discharge shall be 20 gpm (76 L/min) per sprinkler from the five hydraulically most remote sprinklers. [**318**:2.1.2.6.1]

13.23.2 Installation Requirements.

13.23.2.1 Wet pipe automatic sprinkler protection shall be provided throughout facilities containing cleanrooms and clean zones. [**318**:2.1.1]

13.23.2.2* Quick response sprinklers shall be utilized for sprinkler installations within down-flow airstreams in cleanrooms and clean zones. [**318**:2.1.2.2]

13.23.2.3* Sprinklers installed in ductwork shall be spaced a maximum of 20 ft (6.1 m) apart horizontally and 12 ft (3.7 m) apart vertically. [**318**:2.1.2.6.1]

13.23.2.4 A separate indicating control valve shall be provided for sprinklers installed in ductwork. [**318**:2.1.2.6.2]

13.23.2.5 The sprinklers shall be accessible for periodic inspection and maintenance. [**318**:2.1.2.6.5]

13.24 Aircraft Hangars.

13.24.1 Design Requirements. Sprinkler systems installed in aircraft hangars shall comply with NFPA 409, *Standard on Aircraft Hangars.*

13.24.2 Installation Requirements. Sprinkler systems installed in aircraft hangars shall comply with NFPA 409, *Standard on Aircraft Hangars.*

13.25 Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways.

13.25.1 Design Requirements.

13.25.1.1 Passenger handling areas [in airport terminal buildings] shall be classified as ordinary hazard, Group 1 occupancy for the purpose of sprinkler system design. [**415**:2.5.1.1]

13.25.1.2* Other areas of the airport terminal building shall be classified in accordance with Chapter 5 of NFPA 13, based on the occupancy of the area. [**415**:2.5.1.2]

13.25.1.3 Sprinkler System Water Supply. Water supply from public or private sources shall be adequate to supply maximum calculated sprinkler demand plus a minimum of 500 gpm (1893 L/min) for hose streams. The supply shall be available at the rate specified for a period of at least 1 hour. [**415**:2.5.5]

13.25.2 Installation Requirements. (Reserved)

13.26 Aircraft Engine Test Facilities.

13.26.1 Design Requirements.

13.26.1.1* In engine test cells, the minimum design discharge density shall be 0.5 gpm/ft^2 (20.4 mm/min) of protected area. [**423**:5.6.3]

13.26.1.2 In engine test cells, water supplies shall be capable of meeting the largest demand at the design rate plus hose stream demand for a period of 30 minutes. Hose stream demand shall be a minimum of 250 gpm (946 L/min). The hydraulic calculation and the water supply shall be based on the assumption that all sprinklers in the test cell are operating simultaneously. [**423**:5.6.4]

13.26.2 Installation Requirements. (Reserved)

13.27 Liquid and Solid Oxidizers.

13.27.1 Design Requirements.

13.27.1.1 Dry-pipe and double-interlock pre-action sprinkler systems shall not be permitted for protection of buildings or areas containing oxidizers.

Exception: Dry-pipe and double-interlock pre-action systems shall be permitted for protection of Class I oxidizers in noncombustible structures. [430:2.11.3]

13.27.1.2 Sprinkler System Water Supplies.

13.27.1.2.1 Water supplies shall be adequate for the protection of the oxidizer storage by hose streams and automatic sprinklers. The water system shall be capable of providing not less than 750 gpm (2840 L/min) where protection is by means of hose streams, or 500 gpm (1890 L/min) for hose streams in excess of the automatic sprinkler water demand. [**430**:2.11.4.1]

13.27.1.2.2 Duration of the water supply shall be a minimum of 2 hours. [**430**:2.11.4.2]

13.27.1.3 Class 1 Oxidizers. Class 1 oxidizers in noncombustible or combustible containers (paper bags or noncombustible containers with removable combustible liners) shall be designated as a Class 1 commodity; as a Class 2 commodity where contained in fiber packs or noncombustible containers in combustible packaging; and as a Class 3 commodity where contained in plastic containers. [**430**:3.3.2]

13.27.1.4 Class 2 Oxidizers.

13.27.1.4.1* Sprinkler protection for Class 2 oxidizers shall be designed in accordance with Table 13.27.1.4.1. [**430**:4.4.1]

13.27.1.4.2 Storage Protection with In-Rack Sprinklers. In-rack sprinklers shall be designed to provide 30 psi (2.1 bar) on the hydraulically most remote six sprinklers on each level. [**430**:4.4.4, 4.4.4.1]

13.27.1.5 Class 3 Oxidizers.

13.27.1.5.1* Sprinkler protection for Class 3 oxidizers shall be designed in accordance with Table 13.27.1.5.1. [**430**:5.4.1]

13.27.1.5.2 Where more than 200 lb but less than 2300 lb of Class 3 oxidizers are stored in racks, height of such storage shall be limited to 6 ft, and a level of in-rack sprinklers spaced at maximum 8-ft intervals shall be provided over each level of storage.

13.27.1.5.3 Storage Protection with In-Rack Sprinklers. In-rack sprinklers shall be designed to provide 30 psi (2.1 bar) on the hydraulically most remote six sprinklers on each level. [**430**:5.4.4, 5.4.4.1]

13.27.1.6 Class 4 Oxidizers. Sprinkler protection for Class 4 oxidizers shall be installed on a deluge sprinkler system to provide water density of 0.35 gpm (14.3 mm/min) over the entire storage area. [**430**:6.4.1]

13.27.2* Installation Requirements. See NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers.*

Table 13.27.1.4.1 Sprinkler Protection for Class 2 Oxidizers

	Ceiling Sprinklers						
	Storage Height		Density		Area of Application		
Type of Storage	ft	m	gpm/ft^2	L/min/m^2	ft^2	m^2	In-Rack Sprinklers
Palletized or bulk	8	2.4	0.20	8	3750	348	—
Palletized or bulk	12	3.7	0.35	14	3750	348	—
Rack	12	3.7	0.20	8	3750	348	One line above each level of storage except the top level
Rack	16	4.9	0.30	12	2000	186	One line above each level of storage except the top level

Table 13.27.1.5.1 Sprinkler Protection for Class 3 Oxidizers [430:Table 5.4.1]

	Storage Height		Density		Area of Application		
Type of Storage	ft	m	gpm/ft^2	L/min/m^2	ft^2	m^2	In-Rack Sprinklers
Palletized or bulk	5	1.5	0.35	14	5000	465	
Palletized rack or bulk	10	3	0.65	26	5000	465	
Rack	10	3	0.35	14	5000	465	1 level at midpoint of rack

13.28 Storage of Organic Peroxide Formulations.

13.28.1 Design Requirements.

13.28.1.1 Where [automatic sprinkler systems are required per NFPA 432, *Code for the Storage of Organic Peroxide Formulations,* they] shall provide the following discharge densities:

Class I [organic peroxides] — 0.5 gpm/ft^2 (20. 4 mm/min)
Class II [organic peroxides] — 0.4 gpm/ft^2 (16.3 mm/min)
Class III [organic peroxides] — 0.3 gpm/ft^2 (12.2 mm/min)
Class IV [organic peroxides] — 0.25 gpm/ft^2 (10.2 mm/min) [**432**:2.8.2]

13.28.1.2 The system shall be designed to provide the required density over a 3000-ft^2 (279-m^2) area for areas protected by a wet pipe sprinkler system or 3900 ft^2 (363 m^2) for areas protected by a dry pipe sprinkler system. The entire area of any building of less than 3000 ft^2 (279 m^2) shall be used as the area of application. [**432**:2.8.2.1]

13.28.1.3 Sprinkler System Water Supply. Water supplies for automatic sprinkler systems, fire hydrants, and so forth, shall be capable of supplying the anticipated demand for at least 90 minutes. [**432**:2.8.3]

13.28.1.4 Detached Storage of Class I Organic Peroxide Formulations. Sprinkler protection for Class I organic peroxide formulations in quantities exceeding 2000 lb (908 kg) in detached storage shall be of the deluge type. [**432**:5.5.2]

13.28.2 Installation Requirements. Where automatic sprinkler protection is provided for Class I organic peroxide formulations in quantities exceeding 2000 lb (907 kg), it shall be a deluge system. [**432**:5.5.2]

13.29 Advanced Light Water Reactor Electric Generating Plants.

13.29.1 Design Requirements.

13.29.1.1* Sprinkler System Water Supply. The fire water supply shall be calculated on the basis of the largest expected flow rate for a period of 2 hours, but shall not be less than 300,000 gal (1,135,500 L). This flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler system. The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service. [**804**:7.2.1]

13.29.1.2 Yard Mains. The underground yard fire main loop shall be installed to furnish anticipated water requirements. The type of pipe and water treatment shall be design considerations, with tuberculation as one of the parameters. Means for inspecting and flushing the systems shall be provided. [**804**:7.4.1]

13.29.1.3 Cable Tunnels. [804:8.4.2]

13.29.1.3.1 Automatic sprinkler systems shall be designed for a density of 0.3 gpm/ft^2 (12.2 mm/min) for the most remote 100 linear feet (30.5 linear meters) of cable tunnel up to the most remote 2500 ft^2 (232.2 m^2). [**804**:8.4.2.2.1]

13.29.1.3.2 Deluge sprinkler systems or deluge spray systems shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated. The systems shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing. [**804**:8.4.2.2.3]

13.29.1.4 Cable Spreading Room. The cable spreading room shall have an automatic water-based suppression system. The location of sprinklers or spray nozzles shall consider cable tray arrangements to ensure adequate water coverage for areas that could present exposure fire hazards to the cable raceways. Automatic sprinkler systems shall be designed for a density of 0.30 gpm/ft^2 (12.2 L/min·m^2) over the most remote 2500 ft^2 (232.2 m^2). [**804**:8.4.1.1]

13.29.1.5* Beneath Turbine Generator Operating Floor. All areas beneath the turbine generator operating floor shall be protected by an automatic sprinkler or foam-water sprinkler system. The sprinkler system beneath the turbine generator shall take into consideration obstructions from structural members and piping and shall be designed to a minimum density of 0.3 gpm/ft^2 (12.2 mm/min) over a minimum application of 5000 ft^2 (464.5 m^2). [**804:**8.8.2.1]

13.29.1.6* Turbine Generator Bearings.

13.29.1.6.1 Lubricating oil lines above the turbine operating floor shall be protected with an automatic sprinkler system covering those areas subject to oil accumulation, including the area within the turbine lagging (skirt). The automatic sprinkler system shall be designed to a minimum density of 0.30 gpm/ft^2 (12.2 mm/min). [**804:**8.8.4]

13.29.1.6.2 If shaft-driven ventilation systems are used, an automatic preaction sprinkler system providing a density of 0.3 gpm/ft^2 (12.2 mm/min) over the entire area shall be provided. [**804:**8.8.6]

13.29.1.7 Standby Emergency Diesel Generators and Combustion Turbines. Sprinkler and water spray protection systems shall be designed for a 0.25-gpm/ft^2 (10.2-mm/min) density over the entire area. [**804:**8.9.2]

13.29.1.8 Fire Pump Room/House. If sprinkler and water spray systems are provided for fire pump houses, they shall be designed for a minimum density of 0.25 gpm/ft^2 (10.2 mm/min) over the entire fire area. [**804:**8.22]

13.29.1.9 Oil-Fired Boilers. Sprinkler and water spray systems shall be designed for a minimum density of 0.25 gpm/ft^2 (10.2 mm/min) over the entire area. [**804:**8.24.2]

13.29.2 Installation Requirements.

13.29.2.1 Yard Mains, Hydrants, and Building Standpipes. [**804:**7.4]

13.29.2.1.1 Approved visually indicating sectional control valves such as post-indicator valves shall be provided to isolate portions of the main for maintenance or repair without simultaneously shutting off the supply to both primary and backup fire suppression systems. [**804:**7.4.2]

13.29.2.1.2* Sectional control valves shall permit maintaining independence of the individual loop around each unit. For such installations, common water supplies shall also be permitted to be utilized. For multiple-reactor sites with widely separated plants [approaching 1 mi. (1.6 km) or more], separate yard fire main loops shall be used. [**804:**7.4.4]

13.29.2.1.3 Sprinkler systems and manual hose station standpipes shall have connections to the plant underground water main so that a single active failure or a crack in a moderate-energy line can be isolated so as not to impair both the primary and backup fire suppression systems. Alternatively, headers fed from each end are permitted inside buildings to supply both sprinkler and standpipe systems, provided steel piping and fittings meeting the requirements of ANSI/ASME B31.1, *Code for Power Piping,* are used for the headers (up to and including the first valve) supplying the sprinkler systems where such headers are part of the seismically analyzed hose standpipe system. Where provided, such headers are considered an extension of the yard main system. Each sprinkler and standpipe system shall be equipped with an outside screw and yoke (*OS&Y) gate valve or other approved shutoff* valve. [**804:**7.4.7]

13.29.2.2 Cable Concentrations. The location of sprinklers or spray nozzles shall consider cable array arrangements and possible transient combustibles to ensure adequate water coverage for areas that could present exposure fire hazards to the cable raceways. [**804:**8.4.2.2.2]

13.29.2.3 Turbine Building. Deluge sprinkler systems or deluge spray systems shall be zoned to limit the area of protection to that which the drainage system can handle with any two adjacent systems actuated. The systems shall be hydraulically designed with each zone calculated with the largest adjacent zone flowing. [**804:**8.4.2.2.3]

13.30 Light Water Nuclear Power Plants.

13.30.1* Design Requirements. A fire protection water supply of adequate reliability, quantity, and duration shall be provided by one of the two following methods:

(1) Provide a fire protection water supply of not less than two separate 300,000-gal (1,135,500-L) supplies.
(2) Calculate the fire flow rate for 2 hours. This fire flow rate shall be based on 500 gpm (1892.5 L/min) for manual hose streams plus the largest design demand of any sprinkler or fixed water spray system(s) in the power block as determined in accordance with NFPA 13 or NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection.* The fire water supply shall be capable of delivering this design demand with the hydraulically least demanding portion of fire main loop out of service.

[**805:**3.5.1]

13.30.2 Installation Requirements. (Reserved)

13.31 Electric Generating Plants and High Voltage Direct Current Converter Stations. [NFPA 850]

13.31.1* Design Requirements.

13.31.2* Installation Requirements.

13.32 Hydroelectric Generating Plants. [NFPA 851]

13.32.1* Design Requirements.

13.32.2* Installation Requirements.

13.33 Fire Protection in Places of Worship. [NFPA 909]

13.33.1* Design Requirements.

13.33.2 Installation Requirements. (Reserved)

Chapter 14 Plans and Calculations

14.1* Working Plans.

14.1.1* Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled.

14.1.2 Deviation from approved plans shall require permission of the authority having jurisdiction.

14.1.3 Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, and shall show those items from the following list that pertain to the design of the system:

(1) Name of owner and occupant
(2) Location, including street address
(3) Point of compass

(4) Full height cross section, or schematic diagram, including structural member information if required for clarity and including ceiling construction and method of protection for nonmetallic piping
(5) Location of partitions
(6) Location of fire walls
(7) Occupancy class of each area or room
(8) Location and size of concealed spaces, closets, attics, and bathrooms
(9) Any small enclosures in which no sprinklers are to be installed
(10) Size of city main in street and whether dead end or circulating; if dead end, direction and distance to nearest circulating main; and city main test results and system elevation relative to test hydrant *(see A.15.1.8)*.
(11) Other sources of water supply, with pressure or elevation
(12) Make, type, model, and nominal K-factor of sprinklers including sprinkler identification number
(13) Temperature rating and location of high-temperature sprinklers
(14) Total area protected by each system on each floor
(15) Number of sprinklers on each riser per floor
(16) Total number of sprinklers on each dry pipe system, preaction system, combined dry pipe-preaction system, or deluge system
(17) Approximate capacity in gallons of each dry pipe system
(18) Pipe type and schedule of wall thickness
(19) Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions). Where typical branch lines prevail, it shall be necessary to size only one typical line
(20) Location and size of riser nipples
(21) Type of fittings and joints and location of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and the type of fittings or formations to be used
(22) Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable
(23) All control valves, check valves, drain pipes, and test connections
(24) Make, type, model, and size of alarm or dry pipe valve
(25) Make, type, model, and size of preaction or deluge valve
(26) Kind and location of alarm bells
(27) Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment
(28) Private fire service main sizes, lengths, locations, weights, materials, point of connection to city main; the sizes, types and locations of valves, valve indicators, regulators, meters, and valve pits; and the depth that the top of the pipe is laid below grade
(29) Piping provisions for flushing
(30) Where the equipment is to be installed as an addition to an existing system, enough of the existing system indicated on the plans to make all conditions clear
(31) For hydraulically designed systems, the information on the hydraulic data nameplate
(32) A graphic representation of the scale used on all plans
(33) Name and address of contractor
(34) Hydraulic reference points shown on the plan that correspond with comparable reference points on the hydraulic calculation sheets
(35) The minimum rate of water application (density), the design area of water application, in-rack sprinkler demand, and the water required for hose streams both inside and outside
(36) The total quantity of water and the pressure required noted at a common reference point for each system
(37) Relative elevations of sprinklers, junction points, and supply or reference points
(38) If room design method is used, all unprotected wall openings throughout the floor protected
(39) Calculation of loads for sizing and details of sway bracing
(40) The setting for pressure-reducing valves
(41) Information about backflow preventers (manufacturer, size, type)
(42) Information about antifreeze solution used (type and amount)
(43) Size and location of hydrants, showing size and number of outlets and if outlets are to be equipped with independent gate valves. Whether hose houses and equipment are to be provided, and by whom, shall be indicated. Static and residual hydrants that were used in flow tests shall be shown
(44) Size, location, and piping arrangement of fire department connections

14.1.4 The working plan submittal shall include the manufacturer's installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any sprinklers, devices, piping, or fittings.

14.1.5* Working Plans for Automatic Sprinkler Systems with Non–Fire Protection Connections. Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing these devices and piping runs from those of the sprinkler system. Model number, type, and manufacturer's name shall be identified for each piece of auxiliary equipment.

14.2 Water Supply Information.

14.2.1 Water Supply Capacity Information. The following information shall be included:

(1) Location and elevation of static and residual test gauge with relation to the riser reference point
(2) Flow location
(3) Static pressure, psi (bar)
(4) Residual pressure, psi (bar)
(5) Flow, gpm (L/min)
(6) Date
(7) Time
(8) Test conducted by or information supplied by
(9) Other sources of water supply, with pressure or elevation

14.2.2 Water Supply Treatment Information. The following information shall be included where required by 15.1.5:

(1) Type of condition that requires treatment
(2) Type of treatment needed to address the problem
(3) Details of treatment plan

14.3 Hydraulic Calculation Forms.

14.3.1 General. Hydraulic calculations shall be prepared on form sheets that include a summary sheet, detailed worksheets, and a graph sheet. *[See copies of typical forms in Figure A.14.3.2(a), Figure A.14.3.3, and Figure A.14.3.4.]*

14.3.2* Summary Sheet. The summary sheet shall contain the following information, where applicable:

(1) Date
(2) Location
(3) Name of owner and occupant

(4) Building number or other identification
(5) Description of hazard
(6) Name and address of contractor or designer
(7) Name of approving agency
(8) System design requirements, as follows:
   (a) Design area of water application, ft^2 (m^2)
   (b) Minimum rate of water application (density), gpm/ft^2 (mm/min)
   (c) Area per sprinkler, ft^2 (m^2)
(9) Total water requirements as calculated, including allowance for inside hose, outside hydrants, and water curtain and exposure sprinklers
(10) Allowance for in-rack sprinklers, gpm (L/min)
(11) Limitations (dimension, flow, and pressure) on extended coverage or other listed special sprinklers

14.3.3* Detailed Worksheets. Detailed worksheets or computer printout sheets shall contain the following information:

(1) Sheet number
(2) Sprinkler description and discharge constant *(K)*
(3) Hydraulic reference points
(4) Flow in gpm (L/min)
(5) Pipe size
(6) Pipe lengths, center-to-center of fittings
(7) Equivalent pipe lengths for fittings and devices
(8) Friction loss in psi/ft (bar/m) of pipe
(9) Total friction loss between reference points
(10) In-rack sprinkler demand balanced to ceiling demand
(11) Elevation head in psi (bar) between reference points
(12) Required pressure in psi (bar) at each reference point
(13) Velocity pressure and normal pressure if included in calculations
(14) Notes to indicate starting points or reference to other sheets or to clarify data shown
(15)*Diagram to accompany gridded system calculations to indicate flow quantities and directions for lines with sprinklers operating in the remote area
(16) Combined K-factor calculations for sprinklers on drops, armovers, or sprigs where calculations do not begin at the sprinkler

14.3.4* Graph Sheet. A graphic representation of the complete hydraulic calculation shall be plotted on semiexponential graph paper ($Q^{1.85}$) and shall include the following:

(1) Water supply curve
(2) Sprinkler system demand
(3) Hose demand (where applicable)
(4) In-rack sprinkler demand (where applicable)

14.4 Hydraulic Calculation Procedures.

14.4.1* General.

14.4.1.1 A calculated system for a building, or a calculated addition to a system in an existing sprinklered building, shall supersede the rules in this standard governing pipe schedules, except that all systems shall continue to be limited by area.

14.4.1.2 Pipe sizes shall be no less than 1 in. (25.4 mm) nominal for ferrous piping and ¾ in. (19 mm) nominal for copper tubing or nonmetallic piping listed for fire sprinkler service.

14.4.1.3 The size of pipe, number of sprinklers per branch line, and number of branch lines per cross main shall otherwise be limited only by the available water supply.

14.4.1.4 However, sprinkler spacing and all other rules covered in this and other applicable standards shall be observed.

14.4.2 Formulas.

14.4.2.1 Friction Loss Formula.

14.4.2.1.1 Pipe friction losses shall be determined on the basis of the Hazen-Williams formula, as follows:

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}}$$

where:
p = frictional resistance in psi per foot of pipe
Q = flow in gpm
C = friction loss coefficient
d = actual internal diameter of pipe in inches

14.4.2.1.2 For SI units, the following equation shall be used:

$$p_m = 6.05\left(\frac{Q_m^{1.85}}{C^{1.85}d_m^{4.87}}\right)10^5$$

where:
p_m = frictional resistance in bar per meter of pipe
Q_m = flow in L/min
C = friction loss coefficient
d_m = actual internal diameter in mm

14.4.2.2 Velocity Pressure Formula. Velocity pressure shall be determined on the basis of the following formula:

$$P_v = \frac{0.001123Q^2}{D^4}$$

where:
P_v = velocity pressure in psi (SI: 1 psi = 0.0689 bar)
Q = flow in gpm (SI : 1 gal = 3.785 L)
D = inside diameter in inches (SI: 1 in. = 25.4 mm)

14.4.2.3 Normal Pressure Formula. Normal pressure (P_n) shall be determined on the basis of the following formula:

$$P_n = P_t - P_v$$

where:
P_n = normal pressure
P_t = total pressure in psi (bar)
P_v = velocity pressure in psi (bar)

14.4.2.4 Hydraulic Junction Points.

14.4.2.4.1 Pressures at hydraulic junction points shall balance within 0.5 psi (0.03 bar).

14.4.2.4.2 The highest pressure at the junction point, and the total flows as adjusted, shall be carried into the calculations.

14.4.2.4.3 Pressure balancing shall be permitted through the use of a K-factor developed for branch lines or portions of systems using K_p=$Q/(p)^{0.5}$.

14.4.3 Equivalent Pipe Lengths of Valves and Fittings.

14.4.3.1 Pipe and Fittings.

14.4.3.1.1 Table 14.4.3.1.1 shall be used to determine the equivalent length of pipe for fittings and devices unless manufacturer's test data indicate that other factors are appropriate.

14.4.3.1.2 For saddle-type fittings having friction loss greater than that shown in Table 14.4.3.1.1, the increased friction loss shall be included in hydraulic calculations.

Table 14.4.3.1.1 Equivalent Schedule 40 Steel Pipe Length Chart

	Fittings and Valves Expressed in Equivalent Feet of Pipe														
Fittings and Valves	½ in.	¾ in.	1 in.	1¼ in.	1½ in.	2 in.	2½ in.	3 in.	3½ in.	4 in.	5 in.	6 in.	8 in.	10 in.	12 in.
45° elbow	—	1	1	1	2	2	3	3	3	4	5	7	9	11	13
90° standard elbow	1	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90° long-turn elbow	0.5	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee or cross (flow turned 90°)	3	4	5	6	8	10	12	15	17	20	25	30	35	50	60
Butterfly valve	—	—	—	—	—	6	7	10	—	12	9	10	12	19	21
Gate valve	—	—	—	—	—	1	1	1	1	2	2	3	4	5	6
Swing check*	—	—	5	7	9	11	14	16	19	22	27	32	45	55	65

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: Information on ½-in. pipe is included in this table only because it is allowed under 8.14.19.3 and 8.14.19.4.
*Due to the variation in design of swing check valves, the pipe equivalents indicated in this table are considered average.

14.4.3.1.3 Equivalent Feet Modifier.

14.4.3.1.3.1 For internal pipe diameters different from Schedule 40 steel pipe, the equivalent feet shown in Table 14.4.3.1.1 shall be multiplied by a factor derived from the following formula:

$$\left(\frac{\text{Actual inside diameter}}{\text{Schedule 40 steel pipe inside diameter}}\right)^{4.87} = \text{Factor}$$

14.4.3.1.3.2 The factor thus obtained shall be further modified as required by Table 14.4.3.1.1. This table shall apply to other types of pipe listed in Table 14.4.3.1.1 only where modified by factors from 14.4.3.1.1 and 14.4.3.2.

14.4.3.2 *C*-Factors. Table 14.4.3.1.1 shall be used with a Hazen-Williams *C* factor of 120 only. For other values of *C*, the values in Table 14.4.3.1.1 shall be multiplied by the factors indicated in Table 14.4.3.2.

Table 14.4.3.2 *C* Value Multiplier

Value of *C*	100	130	140	150
Multiplying factor	0.713	1.16	1.33	1.51

Note: These factors are based upon the friction loss through the fitting being independent of the *C* factor available to the piping.

14.4.3.3 Valves. Specific friction loss values or equivalent pipe lengths for alarm valves, dry pipe valves, deluge valves, strainers, and other devices shall be made available to the authority having jurisdiction.

14.4.3.4 Differing Values. Specific friction loss values or equivalent pipe lengths for listed fittings not in Table 6.4.1 shall be used in hydraulic calculations where these losses or equivalent pipe lengths are different from those shown in Table 14.4.3.1.1.

14.4.4* Calculation Procedure.

14.4.4.1* For all systems the design area shall be the hydraulically most demanding based on the criteria of Chapter 11, Chapter 12, or the special design approaches in accordance with the requirements of Chapter 13.

14.4.4.1.1 Density-Area Method.

14.4.4.1.1.1 Where the design is based on the density-area method, the design area shall be a rectangular area having a dimension parallel to the branch lines at least 1.2 times the square root of the area of sprinkler operation *(A)* used, which shall permit the inclusion of sprinklers on both sides of the cross main.

14.4.4.1.1.2 Any fractional sprinkler shall be carried to the next higher whole sprinkler.

14.4.4.1.1.3 In systems having branch lines with an insufficient number of sprinklers to fulfill the 1.2 requirement, the design area shall be extended to include sprinklers on adjacent branch lines supplied by the same cross main.

14.4.4.1.2 Room Design Method. Where the design is based on the room design method, the calculation shall be based on the room and communicating space, if any, that is hydraulically the most demanding. *(See 11.2.3.3.)*

14.4.4.2* Gridded Systems.

14.4.4.2.1 For gridded systems, the designer shall verify that the hydraulically most demanding area is being used.

14.4.4.2.2 A minimum of two additional sets of calculations shall be submitted to demonstrate peaking of demand area friction loss when compared to areas immediately adjacent on either side along the same branch lines, unless the requirements of 14.4.4.2.3 are met.

14.4.4.2.3 Computer programs that show the peaking of the demand area friction loss shall be acceptable based on a single set of calculations.

14.4.4.3 Design Densities.

14.4.4.3.1 System piping shall be hydraulically designed using design densities and areas of operation in accordance

with 11.2.3.2 or Chapter 12 as required for the occupancies or hazards involved.

14.4.4.3.2* The density shall be calculated on the basis of floor area of sprinkler operation.

14.4.4.3.3 The area covered by any sprinkler used in hydraulic design and calculations shall be the horizontal distances measured between the sprinklers on the branch line and between the branch lines in accordance with 8.5.2.

14.4.4.3.4* Where sprinklers are installed above and below a ceiling or in a case where more than two areas are supplied from a common set of branch lines, the branch lines and supplies shall be calculated to supply the largest water demand.

14.4.4.4* Design Area Sprinklers.

14.4.4.4.1 Each sprinkler in the design area and the remainder of the hydraulically designed system shall discharge at a flow rate at least equal to the stipulated minimum water application rate (density) multiplied by the area of sprinkler operation.

14.4.4.4.2 The requirements of 14.4.4.4.1 to include every sprinkler in the design area to be included in the system discharge shall not apply and where the area of application is equal to or greater than the minimum allowable area of Figure 11.2.3.1.5 for the appropriate hazard classification (including a 30 percent increase for dry pipe systems), sprinkler discharge in closets, washrooms, and similar small compartments requiring only one sprinkler shall be permitted to be omitted from hydraulic calculations within the area of application. Sprinklers in these small compartments shall, however, be capable of discharging minimum densities in accordance with Figure 11.2.3.1.5.

14.4.4.4.3 The requirements of 14.4.4.4.1 to include every sprinkler in the design area to be included in the system discharge shall not apply and where spray sprinklers and large drop sprinklers are provided above and below obstructions such as wide ducts or tables, the water supply for one of the levels of sprinklers shall be permitted to be omitted from the hydraulic ceiling design calculations within the area of application.

14.4.4.4.4 The requirements of 14.4.4.4.1 to include every sprinkler in the design area to be included in the system discharge shall not apply, and where ESFR sprinklers are installed above and below obstructions, the discharge for up to two sprinklers from one of the levels shall be included with those of the other level in the hydraulic calculation.

14.4.4.4.5 Calculations shall begin at the hydraulically most remote sprinkler.

14.4.4.4.6 The calculated pressure at each sprinkler shall be used to determine the discharge flow rate for that particular sprinkler.

14.4.4.5 Friction Loss. Pipe friction loss shall be calculated in accordance with the Hazen-Williams formula with *C* values from Table 14.4.4.5, as follows:

(1) Include pipe, fittings, and devices such as valves, meters, flow switches in pipes 2 in. or less in size, and strainers, and calculate elevation changes that affect the sprinkler discharge.
(2) Tie-in drain piping shall not be included in the hydraulic calculations.
(3) Calculate the loss for a tee or a cross where flow direction change occurs based on the equivalent pipe length of the piping segment in which the fitting is included.
(4) The tee at the top of a riser nipple shall be included in the branch line, the tee at the base of a riser nipple shall be included in the riser nipple, and the tee or cross at a cross main-feed main junction shall be included in the cross main.
(5) Do not include fitting loss for straight-through flow in a tee or cross.
(6) Calculate the loss of reducing elbows based on the equivalent feet value of the smallest outlet.
(7) Use the equivalent feet value for the standard elbow on any abrupt 90-degree turn, such as the screw-type pattern.
(8) Use the equivalent feet value for the long-turn elbow on any sweeping 90-degree turn, such as a flanged, welded, or mechanical joint-elbow type. *(See Table 14.4.3.1.1.)*
(9) Friction loss shall be excluded for the fitting directly connected to a sprinkler.
(10) Losses through a pressure-reducing valve shall be included based on the normal inlet pressure condition. Pressure loss data from the manufacturer's literature shall be used.

Table 14.4.4.5 Hazen-Williams *C* Values

Pipe or Tube	*C* Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized (all)	120
Plastic (listed) all	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to consider other *C* values.

14.4.4.6* Orifice Plates.

14.4.4.6.1 Unless the requirements of 14.4.4.6.2 or 14.4.4.6.3 are met, orifice plates or sprinklers of different orifice sizes shall not be used for balancing the system.

14.4.4.6.2 Sprinklers with different orifice sizes shall be acceptable for special use such as exposure protection, small rooms or enclosures, or directional discharge. *(See 3.3.20 for definition of small rooms.)*

14.4.4.6.3 Extended-coverage sprinklers with a different orifice size shall be acceptable for part of the protection area where installed in accordance with their listing.

14.4.4.7* Pressures.

14.4.4.7.1 When calculating flow from an orifice, the total pressure (P_t) shall be used, unless the calculation method of 14.4.4.7.2 is utilized.

14.4.4.7.2 Use of the normal pressure (P_n) calculated by subtracting the velocity pressure from the total pressure shall be permitted. Where the normal pressure is used, it shall be used on all branch lines and cross mains where applicable.

14.4.4.7.3 Flow from a sprinkler shall be calculated using the nominal K-factor.

14.4.4.8 Minimum Operating Pressure.

14.4.4.8.1 Minimum operating pressure of any sprinkler shall be 7 psi (0.5 bar).

14.4.4.8.2 Where a higher minimum operating pressure for the desired application is specified in the listing of the sprinkler, this higher pressure shall be required.

14.4.4.9 Maximum Operating Pressure. For extra hazard occupancies, palletized, solid-pile, in bin box, on shelf storage, the maximum operating pressure of any sprinkler shall be 175 psi.

14.5 Pipe Schedules. Pipe schedules shall not be used, except in existing systems and in new systems or extensions to existing systems described in Chapter 11. Water supplies shall conform to 11.2.2.

14.5.1* General.

14.5.1.1 The pipe schedule sizing provisions shall not apply to hydraulically calculated systems.

14.5.1.2 Sprinkler systems having sprinklers with K-factors other than 5.6 nominal, listed piping material other than that covered in Table 6.3.1.1, extra hazard Groups 1 and 2 systems, and exposure protection systems shall be hydraulically calculated.

14.5.1.3 The number of automatic sprinklers on a given pipe size on one floor shall not exceed the number given in 14.5.2, 14.5.3, or 14.5.4 for a given occupancy.

14.5.1.4* Size of Risers. Each system riser shall be sized to supply all sprinklers on the riser on any one floor as determined by the standard schedules of pipe sizes in 14.5.2, 14.5.3, or 14.5.4.

14.5.1.5 Slatted Floors, Large Floor Openings, Mezzanines, and Large Platforms. Buildings having slatted floors or large unprotected floor openings without approved stops shall be treated as one area with reference to pipe sizes, and the feed mains or risers shall be of the size required for the total number of sprinklers.

14.5.1.6 Stair Towers. Stairs, towers, or other construction with incomplete floors, if piped on independent risers, shall be treated as one area with reference to pipe sizes.

14.5.2 Schedule for Light Hazard Occupancies.

14.5.2.1 Branch Lines.

14.5.2.1.1 Unless permitted by 14.5.2.1.2 or 14.5.2.1.3, branch lines shall not exceed eight sprinklers on either side of a cross main.

14.5.2.1.2 Where more than eight sprinklers on a branch line are necessary, lines shall be permitted to be increased to nine sprinklers by making the two end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and the sizes thereafter standard.

14.5.2.1.3 Ten sprinklers shall be permitted to be placed on a branch line, making the two end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and feeding the tenth sprinkler by a 2½-in. (64-mm) pipe.

14.5.2.2 Pipe Sizes.

14.5.2.2.1 Pipe sizes shall be in accordance with Table 14.5.2.2.1.

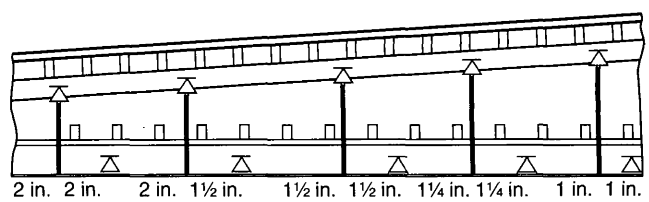
Table 14.5.2.2.1 Light Hazard Pipe Schedules

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in.	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers
3½ in.	100 sprinklers	3½ in.	115 sprinklers
4 in.	See Section 8.2	4 in.	See Section 8.2

For SI units, 1 in. = 25.4 mm.

14.5.2.2.2 Each area requiring more sprinklers than the number specified for 3½-in. (89-mm) pipe in Table 14.5.2.2.1 and without subdividing partitions (not necessarily fire walls) shall be supplied by mains or risers sized for ordinary hazard occupancies.

14.5.2.3 Where sprinklers are installed above and below ceilings in accordance with Figure 14.5.2.3(a) through Figure 14.5.2.3(c), and such sprinklers are supplied from a common set of branch lines or separate branch lines from a common cross main, such branch lines shall not exceed eight sprinklers above and eight sprinklers below any ceiling on either side of the cross main.



For SI units, 1 in. = 25.4 mm.

FIGURE 14.5.2.3(a) Arrangement of Branch Lines Supplying Sprinklers Above and Below a Ceiling.

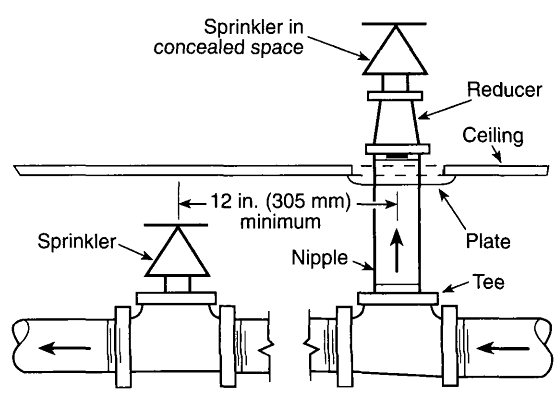


FIGURE 14.5.2.3(b) Sprinkler on Riser Nipple from Branch Line in Lower Fire Area.

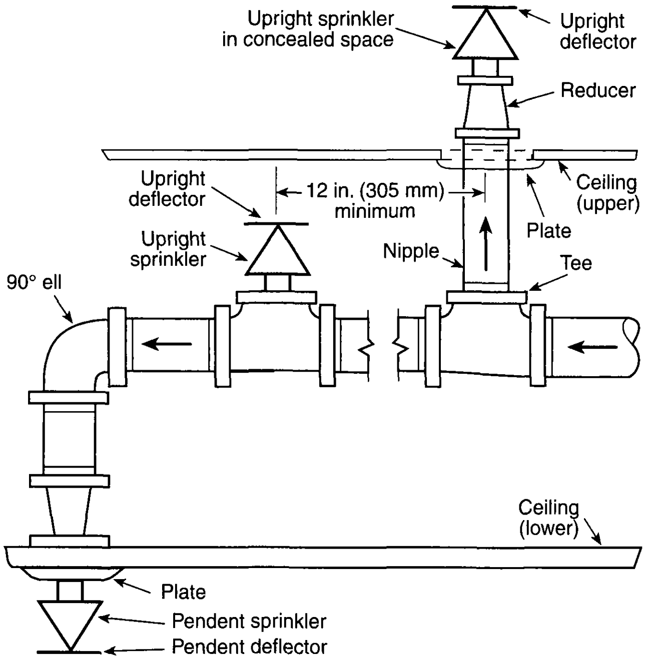


FIGURE 14.5.2.3(c) Arrangement of Branch Lines Supplying Sprinklers Above, in Between, and Below Ceilings.

14.5.2.4 Unless the requirements of 14.5.2.5 are met, pipe sizing up to and including 2½ in. (64 mm) shall be as shown in Table 14.5.2.4 utilizing the greatest number of sprinklers to be found on any two adjacent levels.

Table 14.5.2.4 Number of Sprinklers Above and Below a Ceiling

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	4 sprinklers	1¼ in.	4 sprinklers
1½ in.	7 sprinklers	1½ in.	7 sprinklers
2 in.	15 sprinklers	2 in.	18 sprinklers
2½ in..	50 sprinklers	2½ in.	65 sprinklers

For SI units, 1 in. = 25.4 mm.

14.5.2.5 Branch lines and cross mains supplying sprinklers installed entirely above or entirely below ceilings shall be sized in accordance with Table 14.5.2.2.1.

14.5.2.6* Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 14.5.2.2.1 for 2½-in. (64-mm) pipe, the pipe supplying such sprinklers shall be increased to 3 in. (76 mm) and sized thereafter according to the schedule shown in Table 14.5.2.2.1 for the number of sprinklers above or below a ceiling, whichever is larger.

14.5.3 Schedule for Ordinary Hazard Occupancies.

14.5.3.1 Unless permitted by 14.5.3.2 or 14.5.3.3, branch lines shall not exceed eight sprinklers on either side of a cross main.

14.5.3.2 Where more than eight sprinklers on a branch line are necessary, lines shall be permitted to be increased to nine sprinklers by making the two end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and the sizes thereafter standard.

14.5.3.3 Ten sprinklers shall be permitted to be placed on a branch line, making the two end lengths 1 in. (25.4 mm) and 1¼ in. (33 mm), respectively, and feeding the tenth sprinkler by a 2½-in. (64-mm) pipe.

14.5.3.4 Pipe sizes shall be in accordance with Table 14.5.3.4.

Table 14.5.3.4 Ordinary Hazard Pipe Schedule

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	3 sprinklers	1¼ in.	3 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	10 sprinklers	2 in.	12 sprinklers
2½ in..	20 sprinklers	2½ in.	25 sprinklers
3 in.	40 sprinklers	3 in.	45 sprinklers
3½ in.	65 sprinklers	3½ in.	75 sprinklers
4 in.	100 sprinklers	4 in.	115 sprinklers
5 in.	160 sprinklers	5 in.	180 sprinklers
6 in.	275 sprinklers	6 in.	300 sprinklers
8 in.	See Section 8.2	8 in.	See Section 8.2

For SI units, 1 in. = 25.4 mm.

14.5.3.5 Where the distance between sprinklers on the branch line exceeds 12 ft (3.7 m) or the distance between the branch lines exceeds 12 ft (3.7 m), the number of sprinklers for a given pipe size shall be in accordance with Table 14.5.3.5.

Table 14.5.3.5 Number of Sprinklers — Greater than 12-ft (3.7-m) Separations

Steel		Copper	
2½ in.	15 sprinklers	2½ in	20 sprinklers
3 in.	30 sprinklers	3 in.	35 sprinklers
3½ in.	60 sprinklers	3½ in.	65 sprinklers

For SI units, 1 in. = 25.4 mm.
Note: For other pipe and tube sizes, see Table 14.5.3.4.

14.5.3.6 Where sprinklers are installed above and below ceilings and such sprinklers are supplied from a common set of branch lines or separate branch lines supplied by a common cross main, such branch lines shall not exceed eight sprinklers above and eight sprinklers below any ceiling on either side of the cross main.

14.5.3.7 Pipe sizing up to and including 3 in. (76 mm) shall be as shown in Table 14.5.3.7 in accordance with Figure 14.5.2.3(a), Figure 14.5.2.3(b), and Figure 14.5.2.3(c) utilizing the greatest number of sprinklers to be found on any two adjacent levels.

14.5.3.8 Branch lines and cross mains supplying sprinklers installed entirely above or entirely below ceilings shall be sized in accordance with Table 14.5.3.4 or Table 14.5.3.5.

14.5.3.9* Where the total number of sprinklers above and below a ceiling exceeds the number specified in Table 14.5.3.7 for 3-in. (76-mm) pipe, the pipe supplying such sprinklers

Table 14.5.3.7 Number of Sprinklers Above and Below a Ceiling

Steel		Copper	
1 in.	2 sprinklers	1 in.	2 sprinklers
1¼ in.	4 sprinklers	1¼ in.	4 sprinklers
1½ in.	7 sprinklers	1½ in.	7 sprinklers
2 in.	15 sprinklers	2 in.	18 sprinklers
2½ in..	30 sprinklers	2½ in.	40 sprinklers
3 in.	60 sprinklers	3 in.	65 sprinklers

For SI units, 1 in. = 25.4 mm.

shall be increased to 3½ in. (89 mm) and sized thereafter according to the schedule shown in Table 14.5.2.2.1 or Table 14.5.3.4 for the number of sprinklers above or below a ceiling, whichever is larger.

14.5.3.10 Where the distance between the sprinklers protecting the occupied area exceeds 12 ft (3.7 m) or the distance between the branch lines exceeds 12 ft (3.7 m), the branch lines shall be sized in accordance with either Table 14.5.3.5, taking into consideration the sprinklers protecting the occupied area only, or 14.5.3.7, whichever requires the greater size of pipe.

14.5.4* Extra Hazard Occupancies. Extra hazard occupancies shall be hydraulically calculated.

14.6 Deluge Systems. Open sprinkler and deluge systems shall be hydraulically calculated according to applicable standards.

14.7* Exposure Systems. Exposure sprinklers shall be hydraulically calculated using Table 14.7 and a relative classification of exposures guide number.

14.8 In-Rack Sprinklers.

14.8.1 Pipes to in-rack sprinklers shall be sized by hydraulic calculations.

14.8.2 Water demand of sprinklers installed in racks shall be added to ceiling sprinkler water demand over the same protected area at the point of connection.

14.8.3 The demand shall be balanced to the higher pressure.

Chapter 15 Water Supplies

15.1 General.

15.1.1 Number of Supplies. Every automatic sprinkler system shall have at least one automatic water supply.

15.1.2 Capacity. Water supplies shall be capable of providing the required flow and pressure for the required duration as specified in Chapter 11, Chapter 12, and Chapter 13.

15.1.3 Size of Fire Mains.

15.1.3.1 No pipe smaller than 6 in. (152.4 mm) in diameter shall be installed as a private service main.

15.1.3.2 For mains that do not supply hydrants, sizes smaller than 6 in. (152.4 mm) shall be permitted to be used subject to the following restrictions:

(1) The main supplies only automatic sprinkler systems, open sprinkler systems, water spray fixed systems, foam systems, or Class II standpipe systems.
(2) Hydraulic calculations show that the main will supply the total demand at the appropriate pressure. Systems that are not hydraulically calculated shall have a main at least as large as the system riser.

Table 14.7 Exposure Protection

Section A — Window Sprinklers

Guide Number	Level of Window Sprinkler	Window Sprinkler Orifice Size in.	Window Sprinkler Orifice Size mm	Discharge Coefficient (K-factor)	Flow Rate (*Q*) (gpm)	Application Rate Over 25 ft of Window Area (gpm/ft^2)
1.50 or less	Top 2 levels	⅜	9.5	2.8	7.4	0.30
	Next lower 2 levels	5/16	7.9	1.9	5.0	0.20
	Next lower 2 levels	¼	6.4	1.4	3.7	0.15
1.51–2.20	Top 2 levels	½	12.7	5.6	14.8	0.59
	Next lower 2 levels	7/16	11.1	4.2	11.1	0.44
	Next lower 2 levels	⅜	9.5	2.8	7.4	0.30
2.21–13.15	Top 2 levels	⅝	15.9	11.2	29.6	1.18
	Next lower 2 levels	17/32	13.5	8.0	21.2	0.85
	Next lower 2 levels	½	12.7	5.6	14.8	0.59

Section B — Cornice Sprinklers

Guide Number	Cornice Sprinkler Orifice Size in.	Cornice Sprinkler Orifice Size mm	Application Rate per Lineal Foot (gpm)
1.50 or less	⅜	9.5	0.75
1.51–2.20	½	12.7	1.50
2.21–13.15	⅝	15.9	3.00

For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 gpm/ft^2 = 40.76 mm/min.

15.1.4 Underground Supply Pipe. For pipe schedule systems, the underground supply pipe shall be at least as large as the system riser.

15.1.5* Water Supply Treatment. Water supplies and environmental conditions shall be evaluated for the existence of microbes and conditions that contribute to microbiologically influenced corrosion (MIC). Where conditions are found that contribute to MIC, the owner(s) shall notify the sprinkler system installer and a plan shall be developed to treat the system using one of the following methods:

(1) Install a water pipe that will not be affected by the MIC microbes.
(2) Treat all water that enters the system using an approved biocide.
(3) Implement an approved plan for monitoring the interior conditions of the pipe at established time intervals and locations.

15.1.6 Arrangement.

15.1.6.1 Connection Between Underground and Aboveground Piping.

15.1.6.1.1 The connection between the system piping and underground piping shall be made with a suitable transition piece and shall be properly strapped or fastened by approved devices.

15.1.6.1.2 The transition piece shall be protected against possible damage from corrosive agents, solvent attack, or mechanical damage.

15.1.6.2* Connection Passing Through or Under Foundation Walls. When system piping pierces a foundation wall below grade or is located under the foundation wall, clearance shall be provided to prevent breakage of the piping due to building settlement.

15.1.7* Meters. Where meters are required by other authorities, they shall be listed.

15.1.8* Connection from Waterworks System.

15.1.8.1 Where connections are made from public waterworks systems, it might be necessary to guard against possible contamination of the public supply.

15.1.8.2 The requirements of the public health authority having jurisdiction shall be determined and followed.

15.1.8.3 Where equipment is installed to guard against possible contamination of the public water system, such equipment and devices shall be listed for fire protection service.

15.2 Types.

15.2.1* Connections to Water Works Systems.

15.2.1.1 A connection to a reliable water works system shall be an acceptable water supply source.

15.2.1.2 The volume and pressure of a public water supply shall be determined from waterflow test data. An adjustment to the waterflow test data to account for daily and seasonal fluctuations, possible interruption by flood or ice conditions, large simultaneous industrial use, future demand on the water supply system, or any other condition that could affect the water supply shall be made as appropriate.

15.2.2* Pumps. A single automatically controlled fire pump installed in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* shall be an acceptable water supply source.

15.2.3 Pressure Tanks.

15.2.3.1 Acceptability.

15.2.3.1.1 A pressure tank installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection,* shall be an acceptable water supply source.

15.2.3.1.2 Pressure tanks shall be provided with an approved means for automatically maintaining the required air pressure.

15.2.3.1.3 Where a pressure tank is the sole water supply, there shall also be provided an approved trouble alarm to indicate low air pressure and low water level with the alarm supplied from an electrical branch circuit independent of the air compressor.

15.2.3.1.4 Pressure tanks shall not be used to supply other than sprinklers and hand hose attached to sprinkler piping.

15.2.3.2 Capacity.

15.2.3.2.1 In addition to the requirements of 15.1.2, the water capacity of a pressure tank shall include the extra capacity needed to fill dry pipe or preaction systems where installed.

15.2.3.2.2 The total volume shall be based on the water capacity plus the air capacity required by 15.2.3.3.

15.2.3.3* Water Level and Air Pressure.

15.2.3.3.1 Pressure tanks shall be kept with a sufficient supply of water to meet the demand of the fire protection system as calculated in Chapter 14 for the duration required by Chapter 11, Chapter 12, or Chapter 13.

15.2.3.3.2 The pressure shall be sufficient to push all of the water out of the tank while maintaining the necessary residual pressure (required by Chapter 14) at the top of the system.

15.2.4 Gravity Tanks. An elevated tank installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection,* shall be an acceptable water supply source.

15.2.5 Penstocks or Flumes, Rivers, or Lakes. Water supply connections from penstocks, flumes, rivers, lakes, or reservoirs shall be arranged to avoid mud and sediment and shall be provided with approved double removable screens or approved strainers installed in an approved manner.

Chapter 16 Systems Acceptance

16.1 Approval of Sprinkler Systems and Private Fire Service Mains. The installing contractor shall do the following:

(1) Notify the authority having jurisdiction and owner's representative of the time and date testing will be performed
(2) Perform all required acceptance tests *(see Section 16.2)*
(3) Complete and sign the appropriate contractor's material and test certificate(s) *(see Figure 16.1)*

16.2 Acceptance Requirements.

16.2.1 Hydrostatic Tests.

16.2.1.1 Unless permitted by 16.2.1.2 through 16.2.1.6, all piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bar) and shall maintain that pressure without loss for 2 hours.

Contractor's Material and Test Certificate for Aboveground Piping

PROCEDURE

Upon completion of work, inspection and tests shall be made by the contractor's representative and witnessed by an owner's representative. All defects shall be corrected and system left in service before contractor's personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner's representative's signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority's requirements or local ordinances.

Property name	Date
Property address	

Plans	Accepted by approving authorities (names)		
	Address		
	Installation conforms to accepted plans	☐ Yes	☐ No
	Equipment used is approved If no, explain deviations	☐ Yes	☐ No
Instructions	Has person in charge of fire equipment been instructed as to location of control valves and care and maintenance of this new equipment? If no, explain	☐ Yes	☐ No
	Have copies of the following been left on the premises?	☐ Yes	☐ No
	1. System components instructions	☐ Yes	☐ No
	2. Care and maintenance instructions	☐ Yes	☐ No
	3. NFPA 25	☐ Yes	☐ No
Location of system	Supplies buildings		

Sprinklers	Make	Model	Year of manufacture	Orifice size	Quantity	Temperature rating

Pipe and fittings	Type of pipe ______ Type of fittings ______

Alarm valve or flow indicator	Alarm device			Maximum time to operate through test connection	
	Type	Make	Model	Minutes	Seconds

Dry pipe operating test	Dry valve			Q. O. D.		
	Make	Model	Serial no.	Make	Model	Serial no.

	Time to trip through test connection[1,2]		Water pressure	Air pressure	Trip point air pressure	Time water reached test outlet[1,2]		Alarm operated properly	
	Minutes	Seconds	psi	psi	psi	Minutes	Seconds	Yes	No
Without Q.O.D.									
With Q.O.D.									

If no, explain

[1] Measured from time inspector's test connection is opened

[2] NFPA 13 only requires the 60-second limitation in specific sections

FIGURE 16.1 Contractor's Material and Test Certificate for Aboveground Piping.

<table>
<tr><td rowspan="5">Deluge and preaction valves</td><td colspan="9">Operation ☐ Pneumatic ☐ Electric ☐ Hydraulics</td></tr>
<tr><td colspan="4">Piping supervised ☐ Yes ☐ No</td><td colspan="5">Detecting media supervised ☐ Yes ☐ No</td></tr>
<tr><td colspan="9">Does valve operate from the manual trip, remote, or both control stations? ☐ Yes ☐ No</td></tr>
<tr><td colspan="5">Is there an accessible facility in each circuit for testing? ☐ Yes ☐ No</td><td colspan="4">If no, explain</td></tr>
<tr><td colspan="9">
<table>
<tr><td rowspan="2">Make</td><td rowspan="2">Model</td><td colspan="2">Does each circuit operate supervision loss alarm?</td><td colspan="2">Does each circuit operate valve release?</td><td colspan="2">Maximum time to operate release</td></tr>
<tr><td>Yes</td><td>No</td><td>Yes</td><td>No</td><td>Minutes</td><td>Seconds</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Pressure reducing valve test</td><td colspan="9">
<table>
<tr><td rowspan="2">Location and floor</td><td rowspan="2">Make and model</td><td rowspan="2">Setting</td><td colspan="2">Static pressure</td><td colspan="2">Residual pressure (flowing)</td><td>Flow rate</td></tr>
<tr><td>Inlet (psi)</td><td>Outlet (psi)</td><td>Inlet (psi)</td><td>Outlet (psi)</td><td>Flow (gpm)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Test description</td><td colspan="9"><u>Hydrostatic:</u> Hydrostatic tests shall be made at not less than 200 psi (13.6 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.2 bar) for 2 hours. Differential dry-pipe valve clappers shall be left open during the test to prevent damage. All aboveground piping leakage shall be stopped.

<u>Pneumatic:</u> Establish 40 psi (2.7 bar) air pressure and measure drop, which shall not exceed 1½ psi (0.1 bar) in 24 hours. Test pressure tanks at normal water level and air pressure and measure air pressure drop, which shall not exceed 1½ psi (0.1 bar) in 24 hours.</td></tr>
<tr><td rowspan="6">Tests</td><td colspan="6">All piping hydrostatically tested at ______ psi (____ bar) for ____ hours
Dry piping pneumatically tested ☐ Yes ☐ No
Equipment operates properly ☐ Yes ☐ No</td><td colspan="3">If no, state reason</td></tr>
<tr><td colspan="9">Do you certify as the sprinkler contractor that additives and corrosive chemicals, sodium silicate or derivatives of sodium silicate, brine, or other corrosive chemicals were not used for testing systems or stopping leaks?
☐ Yes ☐ No</td></tr>
<tr><td>Drain test</td><td colspan="4">Reading of gauge located near water supply test connection: ______ psi (____ bar)</td><td colspan="4">Residual pressure with valve in test connection open wide: ______ psi (____ bar)</td></tr>
<tr><td colspan="9">Underground mains and lead-in connections to system risers flushed before connection made to sprinkler piping</td></tr>
<tr><td colspan="6">Verified by copy of the Contractor's Material and Test Certificate for Underground Piping. ☐ Yes ☐ No
Flushed by installer of underground sprinkler piping ☐ Yes ☐ No</td><td colspan="3">Other Explain</td></tr>
<tr><td colspan="6">If powder-driven fasteners are used in concrete, has representative sample testing been satisfactorily completed? ☐ Yes ☐ No</td><td colspan="3">If no, explain</td></tr>
<tr><td>Blank testing gaskets</td><td colspan="2">Number used</td><td colspan="5">Locations</td><td colspan="2">Number removed</td></tr>
<tr><td rowspan="5">Welding</td><td colspan="9">Welding piping ☐ Yes ☐ No</td></tr>
<tr><td colspan="9">If yes. . .</td></tr>
<tr><td colspan="9">Do you certify as the sprinkler contractor that welding procedures comply with the requirements of at least AWS B2.1? ☐ Yes ☐ No</td></tr>
<tr><td colspan="9">Do you certify that the welding was performed by welders qualified in compliance with the requirements of at least AWS B2.1? ☐ Yes ☐ No</td></tr>
<tr><td colspan="9">Do you certify that the welding was carried out in compliance with a documented quality control procedure to ensure that all discs are retrieved, that openings in piping are smooth, that slag and other welding residue are removed, and that the internal diameters of piping are not penetrated? ☐ Yes ☐ No</td></tr>
<tr><td>Cutouts (discs)</td><td colspan="9">Do you certify that you have a control feature to ensure that all cutouts (discs) are retrieved? ☐ Yes ☐ No</td></tr>
</table>

FIGURE 16.1 *Continued*

Hydraulic data nameplate	Nameplate provided ☐ Yes ☐ No	If no, explain
Remarks	Date left in service with all control valves open	
Signatures	Name of sprinkler contractor	
	Tests witnessed by	
	For property owner (signed)	Title / Date
	For sprinkler contractor (signed)	Title / Date
Additional explanations and notes		

FIGURE 16.1 *Continued*

16.2.1.2 Portions of systems normally subjected to system working pressures in excess of 150 psi (10.4 bar) shall be tested as described in 16.2.1.1 at a pressure of 50 psi (3.5 bar) in excess of system working pressure.

16.2.1.3 Where cold weather will not permit testing with water, an interim air test shall be permitted to be conducted as described in 16.2.3.

16.2.1.4 Modifications affecting 20 or fewer sprinklers shall not require testing in excess of system working pressure.

16.2.1.5 Where addition or modification is made to an existing system affecting more than 20 sprinklers, the new portion shall be isolated and tested at not less than 200 psi (13.8 bar) for 2 hours.

16.2.1.6 Modifications that cannot be isolated, such as relocated drops, shall not require testing in excess of system working pressure.

16.2.1.7 Loss shall be determined by a drop in gauge pressure or visual leakage.

16.2.1.8 The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested.

16.2.1.9 Additives, corrosive chemicals such as sodium silicate, or derivatives of sodium silicate, brine, or other chemicals shall not be used while hydrostatically testing systems or for stopping leaks.

16.2.1.10 Piping between the exterior fire department connection and the check valve in the fire department inlet pipe shall be hydrostatically tested in the same manner as the balance of the system.

16.2.1.11 When deluge systems are being hydrostatically tested, plugs shall be installed in fittings and replaced with open sprinklers after the test is completed, or the operating elements of automatic sprinklers shall be removed after the test is completed.

16.2.1.12* The trench shall be backfilled between joints before testing to prevent movement of pipe.

16.2.1.13 Where required for safety measures presented by the hazards of open trenches, the pipe and joints shall be permitted to be backfilled provided the installing contractor takes the responsibility for locating and correcting leakage in excess of that permitted in 16.2.1.8.

16.2.1.14 Provision shall be made for the proper disposal of water used for flushing or testing.

16.2.1.15* Test Blanks.

16.2.1.15.1 Test blanks shall have painted lugs protruding in such a way as to clearly indicate their presence.

16.2.1.15.2 The test blanks shall be numbered, and the installing contractor shall have a recordkeeping method ensuring their removal after work is completed.

16.2.1.16 When subject to hydrostatic test pressures, the clapper of a differential-type valve shall be held off its seat to prevent damaging the valve.

16.2.2 Dry Pipe and Double Interlock System(s) Air Test.

16.2.2.1 In addition to the standard hydrostatic test, an air pressure leakage test at 40 psi (2.8 bar) shall be conducted for 24 hours. Any leakage that results in a loss of pressure in excess of 1½ psi (0.1 bar) for the 24 hours shall be corrected.

16.2.2.2 Where systems are installed in spaces that are capable of being operated at temperatures below 32°F (0°C), air pressure leakage tests required in 16.2.2 shall be conducted at the lowest nominal temperature of the space.

16.2.3 System Operational Tests.

16.2.3.1 Waterflow Devices. Waterflow detecting devices including the associated alarm circuits shall be flow tested through the inspector's test connection and shall result in an audible alarm on the premises within 5 minutes after such flow begins and until such flow stops.

16.2.3.2* Dry Pipe.

16.2.3.2.1 A working test of the dry pipe valve alone and with a quick-opening device, if installed, shall be made by opening the inspector's test connection.

16.2.3.2.2 The test shall measure the time to trip the valve and the time for water to be discharged from the inspector's test connection. All times shall be measured from the time the inspector's test connection is completely opened.

16.2.3.2.3 The results shall be recorded using the contractor's material and test certificate for aboveground piping.

16.2.3.3 Deluge System.

16.2.3.3.1 The automatic operation of a deluge or preaction valve shall be tested in accordance with the manufacturer's instructions.

16.2.3.3.2 The manual and remote control operation, where present, shall also be tested.

16.2.3.4 Main Drain.

16.2.3.4.1 The main drain valve shall be opened and remain open until the system pressure stabilizes.

16.2.3.4.2 The static and residual pressures shall be recorded on the contractor's test certificate.

16.2.3.5 Operating Test.

16.2.3.5.1 Each hydrant shall be fully opened and closed under system water pressure, and dry barrel hydrants shall be checked for proper drainage.

16.2.3.5.2 Where fire pumps are available, this check shall be done with the pumps running.

16.2.3.5.3 All control valves shall be fully closed and opened under system water pressure to ensure proper operation.

16.2.4 Pressure Reducing Valves.

16.2.4.1 Each pressure-reducing valve shall be tested upon completion of installation to ensure proper operation under flow and no-flow conditions.

16.2.4.2 Testing shall verify that the device properly regulates outlet pressure at both maximum and normal inlet pressure conditions.

16.2.4.3 The results of the flow test of each pressure-reducing valve shall be recorded on the contractor's test certificate.

16.2.4.4 The results shall include the static and residual inlet pressures, static and residual outlet pressures, and the flow rate.

16.2.5 Backflow Prevention Assemblies.

16.2.5.1 The backflow prevention assembly shall be forward flow tested to ensure proper operation.

16.2.5.2 The minimum flow rate shall be the system demand, including hose stream demand where applicable.

16.2.6 Exposure Systems. Operating tests shall be made of exposure protection systems upon completion of the installation, where such tests do not risk water damage to the building on which they are installed or to adjacent buildings.

16.3 Circulating Closed Loop Systems.

16.3.1 For sprinkler systems with non–fire protection connections, additional information shall be appended to the Contractor's Material and Test Certificate for Aboveground Piping shown in Figure 16.1 as follows:

(1) Certification that all auxiliary devices, such as heat pumps, circulating pumps, heat exchangers, radiators, and luminaries, if a part of the system, have a pressure rating of at least 175 psi or 300 psi (12.1 bar or 20.7 bar) if exposed to pressures greater than 175 psi (12.1 bar).
(2) All components of sprinkler system and auxiliary system have been pressure tested as a composite system in accordance with 16.2.2.
(3) Waterflow tests have been conducted and waterflow alarms have operated while auxiliary equipment is in each of the possible modes of operation.
(4) With auxiliary equipment tested in each possible mode of operation and with no flow from sprinklers or test connection, waterflow alarm signals did not operate.
(5) Excess temperature controls for shutting down the auxiliary system have been properly field tested.

16.3.2 Discharge tests of sprinkler systems with non–fire protection connections shall be conducted using system test connections described in 6.8.2.

16.3.3 Pressure gauges shall be installed at critical points and readings shall be taken under various modes of auxiliary equipment operation.

16.3.4 Waterflow alarm signals shall be responsive to discharge of water through system test pipes while auxiliary equipment is in each of the possible modes of operation.

16.4 Instructions. The installing contractor shall provide the owner with the following:

(1) All literature and instructions provided by the manufacturer describing proper operation and maintenance of any equipment and devices installed
(2) NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*

16.5* Hydraulic Design Information Sign.

16.5.1 The installing contractor shall identify a hydraulically designed sprinkler system with a permanently marked weatherproof metal or rigid plastic sign secured with corrosion-resistant wire, chain, or other approved means. Such signs shall be placed at the alarm valve, dry pipe valve, preaction valve, or deluge valve supplying the corresponding hydraulically designed area.

16.5.2 The sign shall include the following information:

(1) Location of the design area or areas
(2) Discharge densities over the design area or areas
(3) Required flow and residual pressure demand at the base of the riser
(4) Occupancy classification or commodity classification and maximum permitted storage height and configuration
(5) Hose stream demand included in addition to the sprinkler demand

Chapter 17 Marine Systems

17.1 General.

17.1.1 Chapter 17 outlines the deletions, modifications, and additions that shall be required for marine application.

17.1.2 All other requirements of this standard shall apply to merchant vessel systems except as modified by this chapter.

17.1.3 The following definitions shall be applicable to this chapter *(see Section 3.14)*:

(1) *A-Class Boundary*—A boundary designed to resist the passage of smoke and flame for 1 hour when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials.*
(2) *B-Class Boundary*—A boundary designed to resist the passage of flame for ½ hour when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials.*
(3) *Central Safety Station*—A continuously manned control station from which all of the fire control equipment is monitored. If this station is not the bridge, direct communication with the bridge shall be provided by means other than the ship's service telephone.
(4)**Heat-Sensitive Material*—A material whose melting point is below 1700°F (926.7°C).
(5) *Heel*—The inclination of a ship to one side.
(6) *Heel Angle*—The angle defined by the intersection of a vertical line through the center of a vessel and a line perpendicular to the surface of the water.
(7) *International Shore Connection*—A universal connection complying with ASTM F 1121, *Standard Specification for International Shore Connections for Marine Fire Applications,* to which shoreside fire-fighting hose are to be connected.
(8)**Marine System*—A sprinkler system installed on a ship, boat, or other floating structure that takes its supply from the water on which the vessel floats.
(9)**Marine Thermal Barrier*—An assembly that is constructed of noncombustible materials and made intact with the main structure of the vessel, such as shell, structural bulkheads, and decks. A marine thermal barrier shall meet the requirements of a B-Class boundary. In addition, a marine thermal barrier shall be insulated such that, if tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* for 15 minutes, the average temperature of the unexposed side does not rise more than 250°F (193°C) above the original temperature, nor does the temperature at any one point, including any joint, rise more than 405°F (225°C) above the original temperature.
(10) *Supervision*—A visual and audible alarm signal given at the central safety station to indicate when the system is in operation or when a condition that would impair the satisfactory operation of the system exists. Supervisory alarms shall give a distinct indication for each individual system component that is monitored.
(11) *Survival Angle*—The maximum angle to which a vessel is permitted to heel after the assumed damage required by stability regulations is imposed.
(12) *Type 1 Stair*—A fully enclosed stair that serves all levels of a vessel in which persons can be employed.
(13) *Marine Water Supply*—The supply portion of the sprinkler system from the water pressure tank or the sea suction of the designated sprinkler system pump up to and including the valve that isolates the sprinkler system from these two water sources.

17.1.4* Occupancy Classifications. Marine environment classifications shall be in accordance with Section 5.1.

17.1.5* Partial Installations.

17.1.5.1 Partial installation of automatic sprinklers shall not be permitted, unless the requirements of 17.1.5.2 or 17.1.5.3 are met.

17.1.5.2 Spaces shall be permitted to be protected with an alternative, approved fire suppression system where such areas are separated from the sprinklered areas with a 1 hour–rated assembly.

17.1.5.3 The requirements of 17.1.5.1 shall not apply where specific sections of this standard permit the omission of sprinklers.

17.2 System Components, Hardware, and Use.

17.2.1* Sprinklers shall have a nominal discharge coefficient greater than 1.9.

17.2.2* Sprinkler piping penetrations shall be designed to preserve the fire integrity of the ceiling or bulkhead penetrated.

17.2.3 Spare Sprinklers.

17.2.3.1 The required stock of spare sprinklers shall be carried for each type of sprinkler installed onboard the vessel.

17.2.3.2 Where fewer than six sprinklers of a particular type are installed, 100 percent spares shall be kept in stock.

17.2.3.3 Where applicable, at least one elastometric gasket shall be kept in the cabinet for each fire department connection that is installed onboard the vessel.

17.2.3.4 The cabinet containing spare sprinklers, special wrenches, and elastometric gaskets shall be located in the same central safety station that contains the alarm annunciator panel(s) and supervisory indicators.

17.2.4 System Pipe and Fittings.

17.2.4.1* When ferrous materials are used for piping between the sea chest and zone control valves, these materials shall be protected against corrosion by hot dip galvanizing or by the use of Schedule 80 piping.

17.2.4.2 Maximum design pressure for copper and brass pipe shall not exceed 250 psi (17.2 bar).

17.2.5 Pipe Support.

17.2.5.1* Pipe supports shall comply with the following:

(1) Pipe supports shall be designed to provide adequate lateral, longitudinal, and vertical sway bracing.
(2) The design shall account for the degree of bracing, which varies with the route and operation of the vessel.
(3) Bracing shall be designed to ensure the following:
    (a) Slamming, heaving, and rolling will not shift sprinkler piping, potentially moving sprinklers above ceilings, bulkheads, or other obstructions.
    (b) Piping and sprinklers will remain in place at a steady heel angle at least equal to the maximum required damaged survival angle.

(4) Pipe supports shall be welded to the structure.
(5) Hangers that can loosen during ship motion or vibration, such as screw-down-type hangers, shall not be permitted.
(6) Hangers that are listed for seismic use shall be permitted to be used in accordance with their listing.

17.2.5.2 Sprinkler piping shall be supported by the primary structural members of the vessel such as beams, girders, and stiffeners.

17.2.5.3* The components of hanger assemblies that are welded directly to the ship structure shall not be required to be listed.

17.2.5.4* U-hook sizes shall be no less than that specified in Table 9.1.2.3.

17.2.6 Valves.

17.2.6.1* All indicating, supply, and zone control valves shall be supervised open from a central safety station.

17.2.6.2 Drain and test valves shall meet the applicable requirements of 46 CFR 56.20 and 56.60.

17.2.6.3 Valve markings shall include the information required by 46 CFR 56.20-5(a).

17.2.7 Fire Department Connections and International Shore Connections.

17.2.7.1* A fire department connection and an International Shore Connection shall be installed.

17.2.7.2 The requirements for a fire department connection in 17.2.7.1 shall not apply to vessels that operate primarily on international voyages.

17.2.7.3 Connections shall be located near the gangway or other shore access point so that they are readily accessible to the land-based fire department.

17.2.7.4 Fire department and International Shore Connections shall be colored and marked so that the connections are easily located from the shore access point (i.e., gangway location) and will not be confused with a firemain connection.

17.2.7.5 An 18 in. × 18 in. (0.46 m × 0.46 m) sign displaying the symbol for fire department connection as shown in Table 5.2.1 of NFPA 170, *Standard for Fire Safety Symbols*, shall be placed at the connection so that it is in plain sight from the shore access point.

17.2.7.6 Connections on both sides of the vessel shall be provided where shore access arrangements make it necessary.

17.2.7.7* Fire department connection thread type shall be compatible with fire department equipment.

17.3 System Requirements.

17.3.1* Relief Valves. Relief valves shall be provided on all wet pipe systems.

17.3.2 Spare Detection Devices. The number of spare detection devices or fusible elements used for protection systems that shall be carried per temperature rating is as follows:

(1) Vessels shall have two spare detection devices or fusible elements when operating voyages are normally less than 24 hours.
(2) Vessels shall have four spare detection devices or fusible elements when operating voyages are normally more than 24 hours.

17.3.3 System Piping Supervision. All preaction sprinkler systems shall be supervised regardless of the number of sprinklers supplied.

17.3.4 Circulating Closed Loop Systems. Circulating closed loop systems shall not be permitted.

17.4 Installation Requirements.

17.4.1 Temperature Zones. Intermediate temperature–rated sprinklers shall be installed under a noninsulated steel deck that is exposed to sunlight.

17.4.2* Residential Sprinklers. Residential sprinklers shall be permitted for use only in sleeping accommodation areas.

17.4.3 Window Protection. Where required, windows shall be protected by sprinklers installed at a distance not exceeding 1 ft (0.3 m) from the glazing at a spacing not exceeding 6 ft (1.8 m) such that the entire glazing surface is wetted at a linear density not less than 6 gpm/ft (75 mm/min), unless listed window sprinkler protection systems are installed in accordance with their installation and testing criteria.

17.4.4* Concealed Spaces.

17.4.4.1 Concealed spaces that are constructed of combustible materials, or materials with combustible finishes or that contain combustible materials, shall be sprinklered.

17.4.4.2 The requirements of 17.4.4.1 shall not apply to concealed spaces that contain only nonmetallic piping that is continuously filled with water.

17.4.5 Vertical Shafts.

17.4.5.1 Sprinklers are not required in vertical shafts used as duct, electrical, or pipe shafts that are nonaccessible, noncombustible, and enclosed in an A-Class-rated assembly.

17.4.5.2 Stairway enclosures shall be fully sprinklered.

17.4.6 Bath Modules. Sprinklers shall be installed in bath modules (full room modules) constructed with combustible materials, regardless of room fire load.

17.4.7 Ceiling Types. Drop-out ceilings shall not be used in conjunction with sprinklers.

17.4.8 Return Bends.

17.4.8.1 To prevent sediment buildup, return bends shall be installed in all shipboard sprinkler systems where pendent-type or dry pendent-type sprinklers are used in wet systems *(see Figure 8.14.18.2)*.

17.4.8.2 Consideration shall be given concerning the intrusion of saltwater into the system.

17.4.8.3 Specifically, sprinklers shall not be rendered ineffective by corrosion related to saltwater entrapment within the return bend.

17.4.9 Hose Connections. Sprinkler system piping shall not be used to supply hose connections or hose connections for fire department use.

17.4.10 Heat-Sensitive Piping Materials.

17.4.10.1 Portions of the piping system constructed with a heat-sensitive material shall be subject to the following restrictions:

(1) Piping shall be of non–heat-sensitive type from the sea suction up through the penetration of the last A-Class barrier enclosing the space(s) in which the heat-sensitive piping is installed.

(2) B-Class draft stops shall be fitted not more than 45 ft (13.7 m) apart between the marine thermal barrier *(see definitions in Chapter 3 and 17.1.3)* and the deck or shell.
(3) Portions of a system that are constructed from heat-sensitive materials shall be installed behind a marine thermal barrier, unless the provisions of item (4) are met.
(4)*Piping materials with brazed joints shall not be required to be installed behind a marine thermal barrier, provided the following conditions are met:
  (a) The system is of the wet pipe type.
  (b) The piping is not located in spaces containing boilers, internal combustion engines, or piping containing flammable or combustible liquids or gases under pressure, cargo holds, or vehicle decks.
  (c) A relief valve in compliance with 7.1.2 is installed in each section of piping that is capable of being isolated by a valve(s).
  (d) A valve(s) isolating the section of piping from the remainder of the system is installed in accordance with 17.4.10.2 and 17.4.10.3.

17.4.10.2 Each zone in which heat-sensitive piping is installed shall be fitted with a valve capable of segregating that zone from the remainder of the system.

17.4.10.3 The valve shall be supervised and located outside of the zone controlled and within a readily accessible compartment having A-Class boundaries or within a Type 1 stair.

17.4.11 Discharge of Drain Lines.

17.4.11.1 Drain lines shall not be connected to housekeeping, sewage, or deck drains. Drains shall be permitted to be discharged to bilges.

17.4.11.2 Overboard discharges shall meet the requirements of 46 CFR 56.50-95 and shall be corrosion resistant in accordance with 46 CFR 56.60.

17.4.11.3 Systems that contain water additives that are not permitted to be discharged into the environment shall be specially designed to prevent such discharge.

17.4.11.4 Discharges shall be provided with a down-turned elbow.

17.4.12 Alarm Signals and Devices.

17.4.12.1* A visual and audible alarm signal shall be given at the central safety station to indicate when the system is in operation or when a condition that would impair the satisfactory operation of the system exists.

17.4.12.2 Alarm signals shall be provided for, but not limited to, each of the following: monitoring position of control valves, fire pump power supplies and operating condition, water tank levels and temperatures, zone waterflow alarms, pressure of tanks, and air pressure on dry pipe valves.

17.4.12.3 Alarms shall give a distinct indication for each individual system component that is monitored.

17.4.12.4 An audible alarm shall be given at the central safety station within 30 seconds of waterflow.

17.4.12.5 Waterflow alarms shall be installed for every zone of the sprinkler system.

17.4.12.6 Sprinkler zones shall not encompass more than two adjacent decks or encompass more than one main vertical zone.

17.4.12.7 Electrically operated alarm attachments shall comply with, meet, and be installed in accordance with the requirements of 46 CFR, Subchapter J, "Electrical Engineering."

17.4.12.8 All wiring shall be chosen and installed in accordance with IEEE 45, *Recommended Practice for Electrical Installations on Shipboard.*

17.4.13 Test Connections. Where test connections are below the bulkhead deck, they shall comply with the overboard discharge arrangements of 46 CFR 56.50-95.

17.4.14 Protection of Copper Tubing. Copper tubing materials shall be protected against physical damage in areas where vehicles and stores handling equipment operate.

17.5 Design Approaches.

17.5.1 Design Options.

17.5.1.1 Marine sprinkler systems shall be designed using the hydraulic calculation procedure of Chapter 10.

17.5.1.2 The pipe schedule method shall not be used to determine the water demand requirements.

17.5.2* Window Protection. Minimum water demand requirements shall include sprinklers that are installed for the protection of windows as described in 17.4.3.

17.5.3* Hose Stream Allowance. No allowance for hose stream use shall be required.

17.6 Plans and Calculations.

17.6.1 Additional Information. The pressure tank size, high-pressure relief setting, high and low water alarm settings, low-pressure alarm setting, and pump start pressure shall be provided.

17.6.2 Sprinklers specifically installed for the protection of windows under 17.4.3 shall be permitted to be of a different size from those protecting the remainder of the occupancy classification.

17.6.3 All of the window sprinklers, however, shall be of the same size.

17.6.4* Marine sprinkler systems shall be designed and installed to be fully operational without a reduction in system performance when the vessel is upright and inclined at the angles of inclination specified in 46 CFR 58.01-40.

17.7 Water Supplies.

17.7.1 General. The water supply requirements for marine applications shall be in accordance with Section 17.7.

17.7.2 Pressure Tank.

17.7.2.1 Unless the requirements of 17.7.2.2 are met, a pressure tank shall be provided. The pressure tank shall be sized and constructed so that the following occurs:

(1) The tank shall contain a standing charge of fresh water equal to that specified by Table 17.7.2.1.
(2) The pressure tank shall be sized in accordance with 12.2.3.2.
(3) A glass gauge shall be provided to indicate the correct level of water within the pressure tank.
(4) Arrangements shall be provided for maintaining an air pressure in the tank such that, while the standing charge of water is being expended, the pressure will not be less

than that necessary to provide the design pressure and flow of the hydraulically most remote design area.

(5) Suitable means of replenishing the air under pressure and the fresh water standing charge in the tank shall be provided.

(6) Tank construction shall be in accordance with the applicable requirements of 46 CFR, Subchapter F, "Marine Engineering."

Table 17.7.2.1 Required Water Supply

System Type	Additional Water Volume
Wet pipe system	Flow requirement of the hydraulically most remote system demand for 1 minute
Preaction system Deluge system Dry pipe system	Flow requirement of the hydraulically most remote system demand for 1 minute of system demand plus the volume needed to fill all dry piping

17.7.2.2 Pressure Tank Alternative. In lieu of a pressure tank, a dedicated pump connected to a fresh water tank shall be permitted to be used, provided the following conditions are met:

(1) The pump is listed for marine use and is sized to meet the required system demand.

(2) The suction for the fire pump is located below the suction for the fresh water system so that there shall be a minimum water supply of at least 1 minute for the required system demand.

(3) Pressure switches are provided in the system and the controller for the pump that automatically start the pump within 10 seconds after detection of a pressure drop of more than 5 percent.

(4) There shall be a reduced pressure zone backflow preventer to prevent contamination of the potable water system by salt water.

(5) There are at least two sources of power for this pump. Where the sources of power are electrical, these shall be a main generator and an emergency source of power. One supply shall be taken from the main switchboard, by separate feeder reserved solely for that purpose. This feeder shall be run to an automatic changeover switch situated near the sprinkler unit and the switch shall normally be kept closed to the feeder from the emergency switchboard. The changeover switch shall be clearly labeled, and no other switch shall be permitted in these feeders.

17.7.2.3 Relief Valves.

17.7.2.3.1 Relief valves shall be installed on the tank to avoid overpressurization and false actuation of any dry pipe valve.

17.7.2.3.2 Relief valves shall comply with 46 CFR 54.15-10.

17.7.2.4 Power Source.

17.7.2.4.1 There shall be not less than two sources of power for the compressors that supply air to the pressure tank.

17.7.2.4.2 Where the sources of power are electrical, these shall be a main generator and an emergency source of power.

17.7.2.4.3 One supply shall be taken from the main switchboard, by separate feeders reserved solely for that purpose.

17.7.2.4.4 Such feeders shall be run to a changeover switch situated near the air compressor, and the switch normally shall be kept closed to the feeder from the emergency switchboard.

17.7.2.4.5 The changeover switch shall be clearly labeled, and no other switch shall be permitted in these feeders.

17.7.2.5 Multiple Tanks.

17.7.2.5.1 More than one pressure tank can be installed provided that each is treated as a single water source when determining valve arrangements.

17.7.2.5.2 Check valves shall be installed to prohibit flow from tank to tank or from pump to tank, unless the tank is designed to hold only pressurized air.

17.7.2.6 In systems subject to use with saltwater, valves shall be so arranged as to prohibit contamination of the pressure tank with saltwater.

17.7.2.7* Where applicable, a means shall be provided to restrict the amount of air that can enter the pressure tank from the air supply system. A means shall also be provided to prevent water from backflowing into the air supply system.

17.7.3 Fire Pump.

17.7.3.1 A dedicated, automatically controlled pump that is listed for marine service, which takes suction from the sea, shall be provided to supply the sprinkler system.

17.7.3.2 Where two pumps are required to ensure the reliability of the water supply, the pump that supplies the fire main shall be allowed to serve as the second fire pump.

17.7.3.3* The pump shall be sized to meet the water demand of the hydraulically most demanding area.

17.7.3.4 Pumps shall be designed to not exceed 120 percent of the rated capacity of the pump.

17.7.3.5 The system shall be designed so that, before the supply falls below the design criteria, the fire pump shall be automatically started and shall supply water to the system until manually shut off.

17.7.3.6 Where pump and fresh water tank arrangement is used in lieu of the pressure tank, there must be a pressure switch that senses a system pressure drop of 25 percent, and the controller must automatically start the fire pump(s) if pressure is not restored within 20 seconds.

17.7.3.7 There shall be not less than two sources of power supply for the fire pumps. Where the sources of power are electrical, these shall be a main generator and an emergency source of power.

17.7.3.8 One supply shall be taken from the main switchboard by separate feeders reserved solely for that purpose.

17.7.3.9 Such feeders shall be run to a changeover switch situated near to the sprinkler unit, and the switch normally shall be kept closed to the feeder from the emergency switchboard.

17.7.3.10 The changeover switch shall be clearly labeled, and no other switch shall be permitted in these feeders.

17.7.3.11 Test Valves.

17.7.3.11.1 A test valve(s) shall be installed on the discharge side of the pump with a short open-ended discharge pipe.

17.7.3.11.2 The area of the pipe shall be adequate to permit the release of the required water output to supply the demand of the hydraulically most remote area.

17.7.3.12 Multiple Pumps.

17.7.3.12.1 Where two fire pumps are required to ensure the reliability of the water supply, each fire pump shall meet the requirements of 17.7.3.1 through 17.7.3.4.

17.7.3.12.2 In addition, a system that is required to have more than one pump shall be designed to accommodate the following features:

(1)*Pump controls and system sensors shall be arranged such that the secondary pump will automatically operate if the primary pump fails to operate or deliver the required water pressure and flow. *[Figure A.17.7.3.12.2(1) is an example of an acceptable dual pump arrangement.]*
(2) Both pumps shall be served from normal and emergency power sources. However, where approved by the authority having jurisdiction, the secondary pump shall be permitted to be nonelectrically driven.
(3) Pump failure or operation shall be indicated at the central safety station.

17.7.3.13* If not specifically prohibited, the fire pump that supplies the fire main shall be permitted to be used as the second pump, provided the following conditions are met:

(1) The pump is adequately sized to meet the required fire hose and sprinkler system pressure and flow demands simultaneously.
(2) The fire main system is segregated from the sprinkler system by a normally closed valve that is designed to automatically open upon failure of the designated fire pump.
(3) The fire pump that supplies the fire main is automatically started in the event of dedicated fire pump failure or loss of pressure in the sprinkler main. *(See Figure A.17.7.3.13.)*

17.7.4 Water Supply Configurations.

17.7.4.1 The pressure tank and fire pump shall be located in a position reasonably remote from any machinery space of Category A.

17.7.4.2 All valves within the water supply piping system shall be supervised.

17.7.4.3 Only fresh water shall be used as the initial charge within the piping network.

17.7.4.4 The sprinkler system shall be cross-connected with the ship's fire main system and fitted with a lockable screw-down nonreturn valve such that backflow from the sprinkler system to the fire main is prevented.

17.7.4.5 The piping, tanks, and pumps that make up the water supply shall be installed in accordance with the applicable requirements of 46 CFR, Subchapter F, "Marine Engineering."

17.7.4.6* When a shore water supply is to be used during extended dockside periods, the water supply shall be qualified in the manner described in 15.2.1.

17.7.4.7 Tests shall be conducted in accordance with the requirements of the local shore-based authority having jurisdiction.

17.7.4.8 The water supply information listed in Section 11.3 shall then be provided to the authority having jurisdiction.

17.8 System Acceptance.

17.8.1 Hydrostatic Tests. In addition to the interior piping, the test required by 16.2.1.10 shall also be conducted on all external water supply connections including international shore and fireboat connections.

17.8.2 Alarm Test. A waterflow test shall result in an alarm at the central safety station within 30 seconds after flow through the test connection begins.

17.8.3 Operational Tests.

17.8.3.1 Pressure tank and pump operation, valve actuation, and waterflow shall also be tested.

17.8.3.2 Pump operation and performance shall be tested in accordance with Chapter 14 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

17.9 System Instructions and Maintenance.

17.9.1 Instructions for operation, inspection, maintenance, and testing shall be kept on the vessel.

17.9.2 Records of inspections, tests, and maintenance required by NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* shall also be kept on the vessel.

Chapter 18 System Inspection, Testing, and Maintenance

18.1* General. A sprinkler system installed in accordance with this standard shall be properly inspected, tested, and maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* to provide at least the same level of performance and protection as designed.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 This standard provides a range of sprinkler system approaches, design development alternatives, and component options that are all acceptable. Building owners and their designated representatives are advised to carefully evaluate proposed selections for appropriateness and preference.

A.1.2 Since its inception, this document has been developed on the basis of standardized materials, devices, and design practices. However, Section 1.2 and other subsections such as 6.3.6 and 8.4.9 allow the use of materials and devices not specifically designated by this standard, provided such use is within parameters established by a listing organization. In using such materials or devices, it is important that all conditions, requirements, and limitations of the listing be fully understood and accepted and that the installation be in complete accord with such listing requirements.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.3 Bathroom. A room is still considered a bathroom if it contains just a toilet. Additionally, two bathrooms can be adjacent to each other and are considered separate rooms provided they are enclosed with the required level of construction.

A.3.3.15 Miscellaneous Storage. The sprinkler system design criteria for miscellaneous storage at heights below 12 ft (3.7 m) is covered by this standard in Chapter 12. Chapter 12 describes design criteria and Section 8.2 describes installation requirements (area limits). These requirements apply to all storage of 12 ft (3.7 m) or less in height.

A.3.3.18 Reinforced Plastic Pallet. See Figure A.3.3.18(a) and Figure A.3.3.18(b).

A.3.3.21 Sprinkler System. A sprinkler system is considered to have a single system riser control valve. The design and installation of water supply facilities such as gravity tanks, fire pumps, reservoirs, or pressure tanks are covered by NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* and NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

A.3.4.6 Gridded Sprinkler System. See Figure A.3.4.6.

A.3.4.7 Looped Sprinkler System. See Figure A.3.4.7.

A.3.4.8 Preaction Sprinkler System. The actuating means of the valve are described in 7.3.2.1. Actuation of the detection system and sprinklers in the case of double-interlocked systems opens a valve that permits water to flow into the sprinkler piping system and to be discharged from any sprinklers that are open.

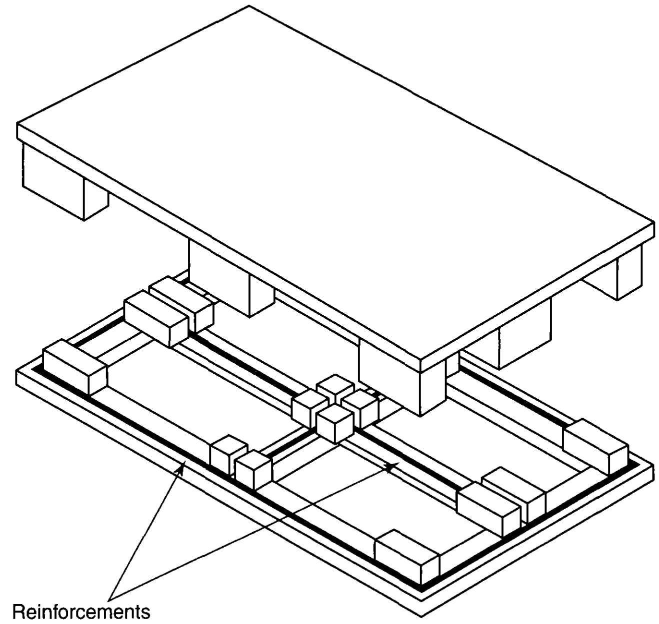


FIGURE A.3.3.18(a) Cut-Away Reinforced Plastic Pallet.

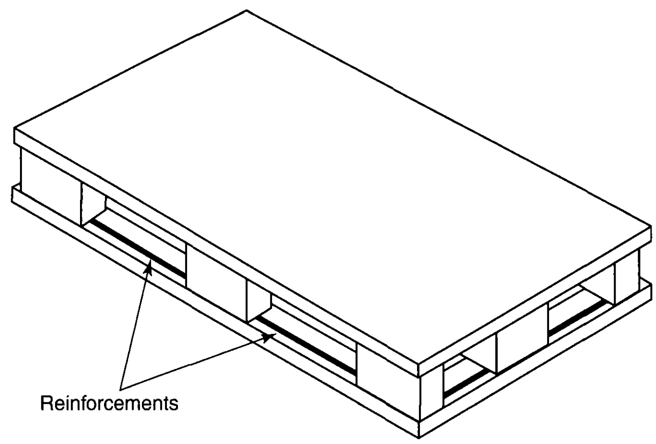


FIGURE A.3.3.18(b) Assembled Reinforced Plastic Pallet.

A.3.5 See Figure A.3.5.

A.3.6.1 General. The response time index (RTI) is a measure of the sensitivity of the sprinkler's thermal element as installed in a specific sprinkler. It is usually determined by plunging a sprinkler into a heated laminar airflow within a test oven. The plunge test is not currently applicable to certain sprinklers.

The RTI is calculated using the following:

(1) The operating time of the sprinkler
(2) The operating temperature of the sprinkler's heat-responsive element (as determined in a bath test)
(3) The air temperature of the test oven
(4) The air velocity of the test oven
(5) The sprinkler's conductivity *(c)* factor, which is the measure of conductance between the sprinkler's heat-responsive element and the sprinkler oven mount

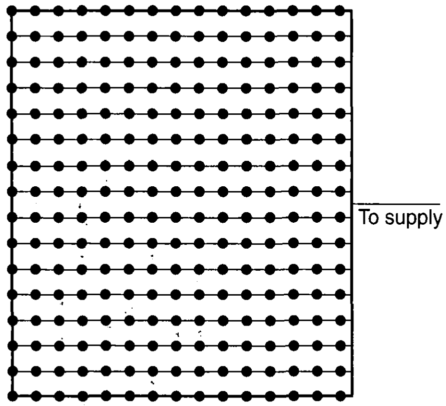


FIGURE A.3.4.6 Gridded System.

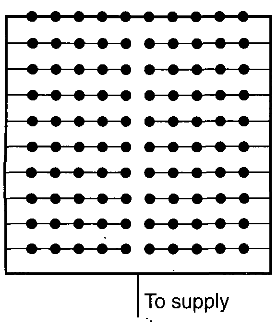


FIGURE A.3.4.7 Looped System.

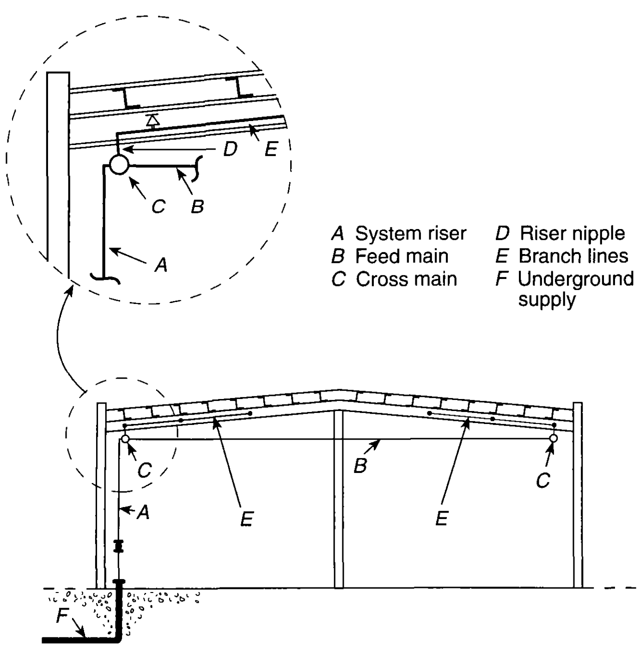


FIGURE A.3.5 Building Elevation Showing Parts of Sprinkler Piping System.

Other factors affecting response include the temperature rating, sprinkler position, fire exposure, and radiation.

ISO standard 6182-1 currently recognizes the RTI range of greater than 50 (meters-seconds)$^{1/2}$ and less than 80 (meters-seconds)$^{1/2}$ as special response. Such sprinklers can be recognized as special sprinklers under 8.4.9.1.

It should be recognized that the term *fast response* (like the term *quick response* used to define a particular type of sprinkler) refers to the thermal sensitivity within the operating element of a sprinkler, not the time of operation in a particular installation. There are many other factors, such as ceiling height, spacing, ambient room temperature, and distance below ceiling, that affect the time of response of sprinklers. In most fire scenarios, sprinkler activation times will be shortest where the thermal elements are located 1 in. (25.4 mm) to 3 in. (76.2 mm) below the ceiling. A fast response sprinkler is expected to operate quicker than a standard response sprinkler in the same installation orientation. For modeling purposes, concealed sprinklers can be considered equivalent to pendent sprinklers having a similar thermal response sensitivity installed 12 in. (305 mm) below smooth unobstructed ceilings, and recessed sprinklers can be considered equivalent to pendent sprinklers having a similar thermal response sensitivity installed 8 in. (203 mm) below smooth unobstructed ceilings.

A.3.6.2.1 Early Suppression Fast-Response (ESFR) Sprinkler. It is important to realize that the effectiveness of these highly tested and engineered sprinklers depends on the combination of fast response and the quality and uniformity of the sprinkler discharge. It should also be realized that ESFR sprinklers cannot be relied upon to provide fire control, let alone suppression, if they are used outside the guidelines specified in Chapter 12.

A.3.6.2.7 Quick-Response Early Suppression (QRES) Sprinkler. Research into the development of QRES sprinklers is continuing under the auspices of the National Fire Protection Research Foundation. It is expected that the proposed design criteria will be added to the standard when a thorough analysis of the test data is completed.

A.3.6.2.12 Specific Application Control Mode Sprinkler (for Storage Use). Examples include large drop sprinklers or listed at a minimum operating pressure or density with a specific number of operating sprinklers — for example, specific application sprinklers.

A.3.6.4.2 Dry Sprinkler. Under certain ambient conditions, wet pipe systems having dry-pendent (or upright) sprinklers can freeze due to heat loss by conduction. Therefore, due consideration should be given to the amount of heat maintained in the heated space, the length of the nipple in the heated space, and other relevant factors.

Dry sprinklers are intended to extend into an unheated area from a wet pipe system or to be used on a dry pipe system.

A.3.7.1 Obstructed Construction. The following are examples of obstructed construction. The definitions are provided to assist the user in determining the type of construction feature.

(1) *Beam and Girder Construction.* The term *beam and girder construction* as used in this standard includes noncombustible and combustible roof or floor decks supported by wood beams of 4 in. (102 mm) or greater nominal thickness or concrete or steel beams spaced 3 ft to 7½ ft (0.9 m to 2.3 m) on center and either supported on or framed into girders. [Where supporting a wood plank deck, this in-

cludes semi-mill and panel construction, and where supporting (with steel framing) gypsum plank, steel deck, concrete, tile, or similar material, this includes much of the so-called noncombustible construction.]

(2) *Concrete Tee Construction.* The term *concrete tee construction* as it is used in this standard refers to solid concrete members with stems (legs) having a nominal thickness less than the nominal height. See Figure A.3.7.1(a) for examples of concrete tee construction.

(3) *Composite Wood Joist Construction.* The term *composite wood joist construction* refers to wood beams of "I" cross section constructed of wood flanges and solid wood web, supporting a floor or roof deck. Composite wood joists can vary in depth up to 48 in. (1.2 m), can be spaced up to 48 in. (1.2 m) on centers, and can span up to 60 ft (18 m) between supports. Joist channels should be firestopped to the full depth of the joists with material equivalent to the web construction so that individual channel areas do not exceed 300 ft^2 (27.9 m^2). *[See Figure A.3.7.1(b) for an example of composite wood joist construction.]*

(4) *Panel Construction.* The term *panel construction* as used in this standard includes ceiling panels formed by members capable of trapping heat to aid the operation of sprinklers and limited to a maximum of 300 ft^2 (27.9 m^2) in area. There should be no unfilled penetrations in the cross sectional area of the bounding structural members including the interface at the roof. Beams spaced more than 7½ ft (2.3 m) apart and framed into girders qualify as panel construction, provided the 300-ft^2 (27.9-m^2) area limitation is met.

(5) *Semi-Mill Construction.* The term *semi-mill construction* as used in this standard refers to a modified standard mill construction, where greater column spacing is used and beams rest on girders.

(6) *Wood Joist Construction.* The term *wood joist construction* refers to solid wood members of rectangular cross section, which can vary from 2 in. to 4 in. (51 mm to 102 mm) nominal width and can be up to 14 in. (356 mm) nominal depth, spaced up to 3 ft (0.9 m) on centers, and can span up to 40 ft (12 m) between supports, supporting a floor or roof deck. Solid wood members less than 4 in. (102 mm) nominal width and up to 14 in. (356 mm) nominal depth, spaced more than 3 ft (0.9 m) on centers, are also considered as wood joist construction.

(7) *Bar Joist Construction with Fireproofing.* In order to meet building codes, bar joists are often covered with fireproofing materials. In such an event, if greater than 30 percent of the area of the joist is obstructed, it should be considered obstructed construction.

A.3.7.2 Unobstructed Construction. The following are examples of unobstructed construction. The definitions are provided to assist the user in determining the type of construction feature.

(1) *Bar Joist Construction.* The term *bar joist construction* refers to construction employing joists consisting of steel truss-shaped members. Wood truss-shaped members, which consist of wood top and bottom chord members not exceeding 4 in. (102 mm) in depth with steel tube or bar webs, are also defined as bar joists. Bar joists include noncombustible or combustible roof or floor decks on bar joist construction. *[See Figure A.3.7.2(a) and Figure A.3.7.2(b) for examples of bar joist construction.]*

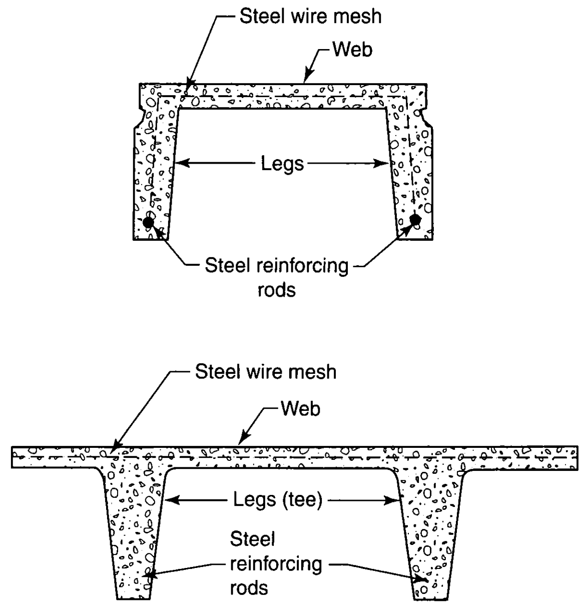


FIGURE A.3.7.1(a) Typical Concrete Tee Construction.

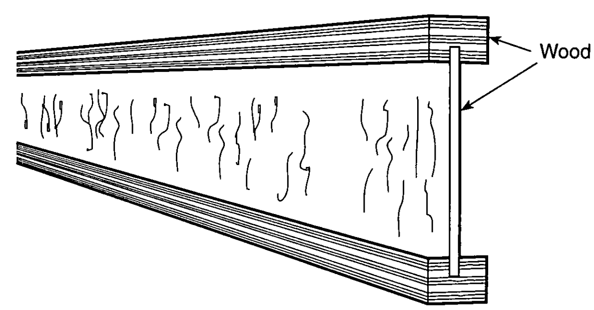


FIGURE A.3.7.1(b) Typical Composite Wood Joist Construction.

(2) *Open-Grid Ceilings.* The term *open-grid ceilings* as used in this standard are ceilings in which the openings are ¼ in. (6.4 mm) or larger in the least dimension, the thickness of the ceiling material does not exceed the least dimension of the openings, and the openings constitute at least 70 percent of the ceiling area.

(3) *Smooth Ceiling Construction.* The term *smooth ceiling construction* as used in this standard includes the following:
   (a) Flat slab, pan-type reinforced concrete
   (b) Continuous smooth bays formed by wood, concrete, or steel beams spaced more than 7½ ft (2.3 m) on centers — beams supported by columns, girders, or trusses
   (c) Smooth roof or floor decks supported directly on girders or trusses spaced more than 7½ ft (2.3 m) on center
   (d) Smooth monolithic ceilings of at least ¾ in. (19 mm) of plaster on metal lath or a combination of materials of equivalent fire-resistive rating attached to the underside of wood joists, wood trusses, and bar joists
   (e) Open-web-type steel beams, regardless of spacing

(f) Smooth shell-type roofs, such as folded plates, hyperbolic paraboloids, saddles, domes, and long barrel shells
(g) Suspended ceilings of combustible or noncombustible construction
(h) Smooth monolithic ceilings with fire resistance less than that specified under item (d) attached to the underside of wood joists, wood trusses, and bar joists

Combustible or noncombustible floor decks are permitted in the construction specified in A.3.7.2(3)(b) through (f). Item (b) would include standard mill construction.

(4) *Standard Mill Construction.* The term *standard mill construction* as used in this standard refers to heavy timber construction as defined in NFPA 220, *Standard on Types of Building Construction.*
(5) *Wood Truss Construction.* The term *wood truss construction* refers to parallel or pitched wood chord members connected by open wood members (webbing) supporting a roof or floor deck. Trusses with steel webbing, similar to bar joist construction, having top and bottom wood chords exceeding 4 in. (102 mm) in depth, should also be considered wood truss construction. *[See Figure A.3.7.2(c).]*

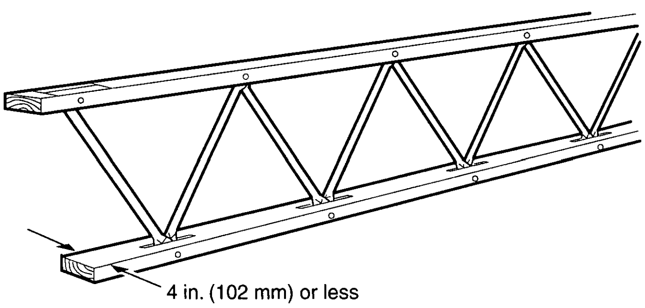


FIGURE A.3.7.2(a) Wood Bar Joist Construction.

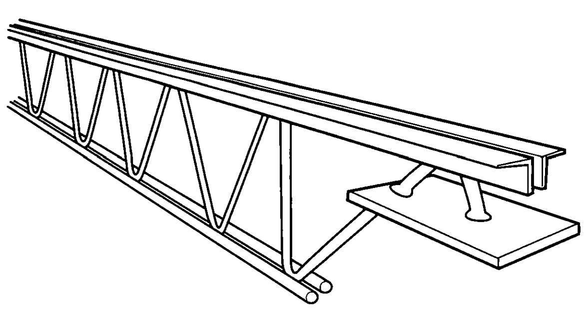


FIGURE A.3.7.2(b) Open-Web Bar Joist Construction.

A.3.8.1 Private Fire Service Main. See Figure A.3.8.1.

A.3.9.1.2 Open Array. Fire tests conducted to represent a closed array utilized 6-in. (152-mm) longitudinal flues and no transverse flues. Fire tests conducted to represent an open array utilized 12-in. (305-mm) longitudinal flues.

A.3.9.2 Available Height for Storage. For new sprinkler installations, the maximum height of storage is the height at which commodities can be stored above the floor where the minimum required unobstructed space below sprinklers is maintained. For the evaluation of existing situations, the maximum

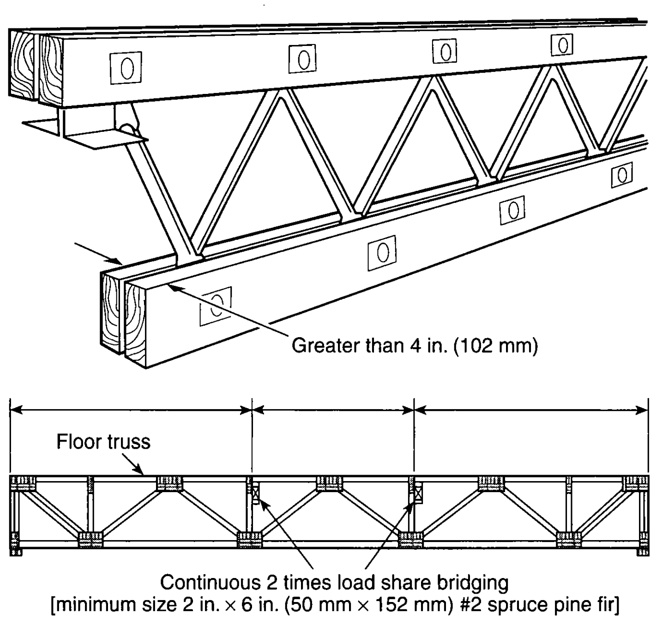


Figure A.3.7.2(c) Examples of Wood Truss Construction.

height of storage is the maximum existing height, if space between the sprinklers and storage is equal to or greater than required.

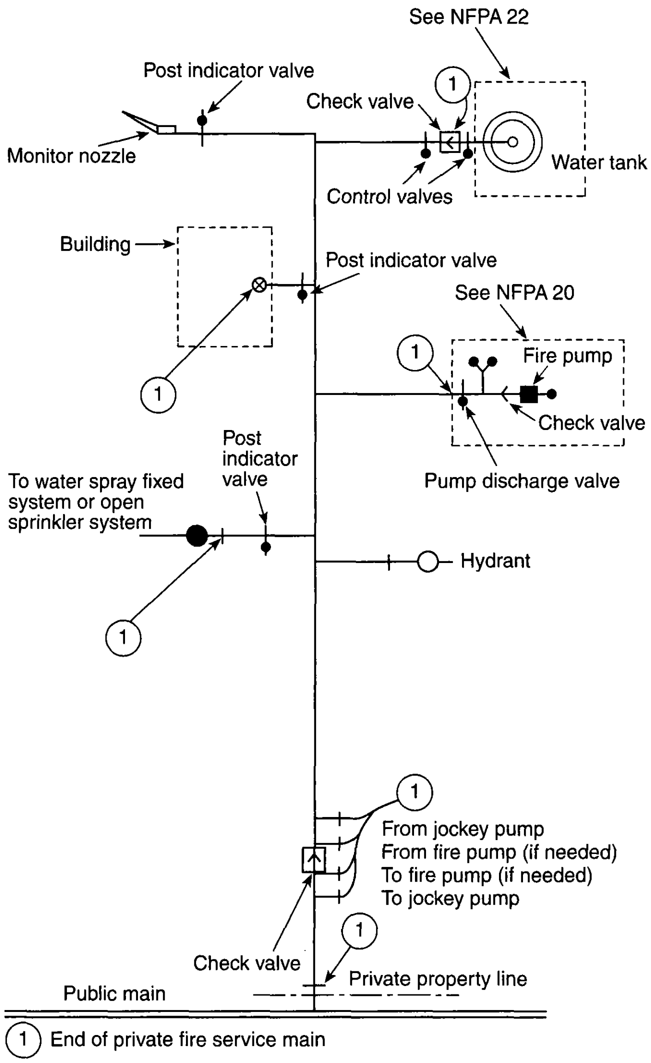
A.3.9.6 Compartmented. Cartons used in most of the Factory Mutual–sponsored plastic tests involved an ordinary 200-lb (90.7-kg) test of outside corrugated cartons with five layers of vertical pieces of corrugated carton used as dividers on the inside. There were also single horizontal pieces of corrugated carton between each layer.

Other tests sponsored by the Society of Plastics Industry, Industrial Risk Insurers, Factory Mutual, and Kemper used two vertical pieces of carton (not corrugated) to form an "X" in the carton for separation of product. This arrangement was not considered compartmented, as the pieces of carton used for separations were flexible (not rigid), and only two pieces were used in each carton.

A.3.9.7 Container (Shipping, Master, or Outer Container). The term *container* includes items such as cartons and wrappings. Fire-retardant containers or tote boxes do not by themselves create a need for automatic sprinklers unless coated with oil or grease. Containers can lose their fire-retardant properties if washed. For obvious reasons, they should not be exposed to rainfall.

A.3.9.14 Pile Stability, Stable Piles. Pile stability performance has been shown to be a difficult factor to judge prior to a pile being subjected to an actual fire. In the test work completed, compartmented cartons *(see A.3.9.6, Compartmented)* have been shown to be stable under fire conditions. Tests also indicated cartons that were not compartmented tended to be unstable under fire conditions.

Storage on pallets, compartmented storage, and plastic components that are held in place by materials that do not deform readily under fire conditions are examples of stable storage.



Note: The piping (aboveground or buried) shown is specific as to the end of the private fire service main and schematic only for illustrative purposes beyond. Details of valves and their location requirements are covered in the specific standard involved.

FIGURE A.3.8.1 Typical Private Fire Service Main.

A.3.9.15 Pile Stability, Unstable Piles. Leaning stacks, crushed bottom cartons, and reliance on combustible bands for stability are examples of potential pile instability under a fire condition. An increase in pile height tends to increase instability.

A.3.10.1 Aisle Width. See Figure A.3.10.1.

A.3.10.4 Conventional Pallets. See Figure A.3.10.4.

A.3.10.7 Longitudinal Flue Space. See Figure A.3.10.7.

A.3.10.8 Rack. Rack storage as referred to in this standard contemplates commodities in a rack structure, usually steel. Many variations of dimensions are found. Racks can be single-row, double-row, or multiple-row, with or without solid shelves. The standard commodity used in most of the tests was 42 in. (1.07 m) on a side. The types of racks covered in this standard are as follows:

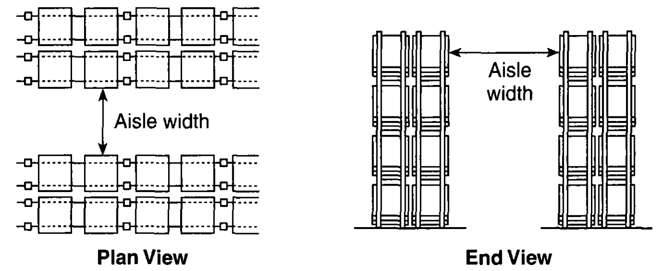


FIGURE A.3.10.1 Illustration of Aisle Width.

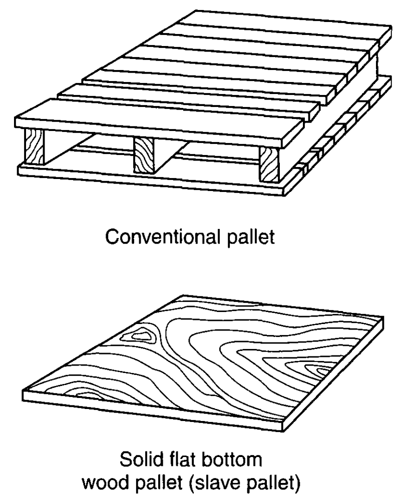


FIGURE A.3.10.4 Typical Pallets.

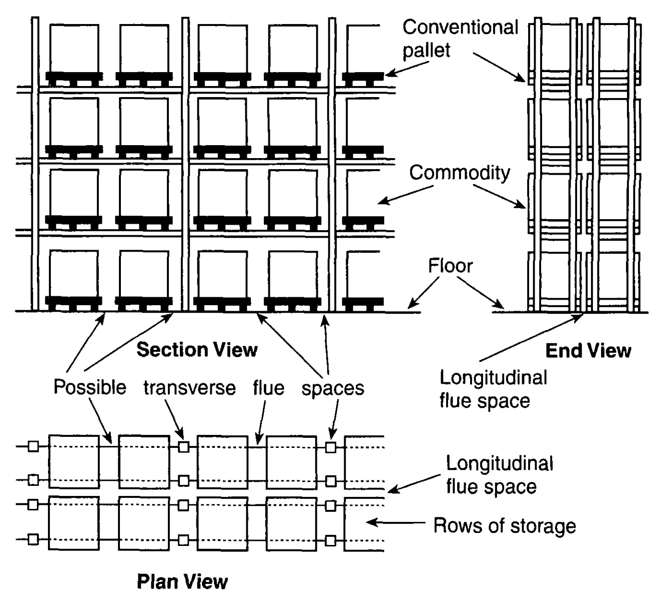


FIGURE A.3.10.7 Typical Double-Row (Back-to-Back) Rack Arrangement.

(1) *Double-Row Racks.* Pallets rest on two beams parallel to the aisle. Any number of pallets can be supported by one pair of beams. *[See Figure A.3.10.8(a) through Figure A.3.10.8(d).]*
(2) *Automatic Storage-Type Rack.* The pallet is supported by two rails running perpendicular to the aisle. *[See Figure A.3.10.8(e).]*
(3) *Multiple-Row Racks More than Two Pallets Deep, Measured Aisle to Aisle.* These racks include drive-in racks, drive-through racks, flow-through racks, portable racks arranged in the same manner, and conventional or automatic racks with aisles less than 42 in. (1.07 m) wide. *[See Figure A.3.10.8(f) through Figure A.3.10.8(k).]*
(4) *Movable Racks.* Movable racks are racks on fixed rails or guides. They can be moved back and forth only in a horizontal, two-dimensional plane. A moving aisle is created as abutting racks are either loaded or unloaded, then moved across the aisle to abut other racks. *[See Figure A.3.10.8(k).]*
(5) *Solid Shelving.* Conventional pallet racks with plywood shelves on the shelf beams *[see Figure A.3.10.8(c) and Figure A.3.10.8(d)]*. These racks are used in special cases. *(See Chapter 12.)*
(6) *Cantilever Rack.* The load is supported on arms that extend horizontally from columns. The load can rest on the arms or on shelves supported by the arms. *[See Figure A.3.10.8(j).]*

Load depth in conventional or automatic racks should be considered a nominal 4 ft (1.22 m). *[See Figure A.3.10.8(b).]*

A.3.11.4 Miscellaneous Tire Storage. The limitations on the type and size of storage are intended to identify those situations where tire storage is present in limited quantities and incidental to the main use of the building. Occupancies such as aircraft hangars, automobile dealers, repair garages, retail storage facilities, automotive and truck assembly plants, and mobile home assembly plants are types of facilities where miscellaneous storage could be present.

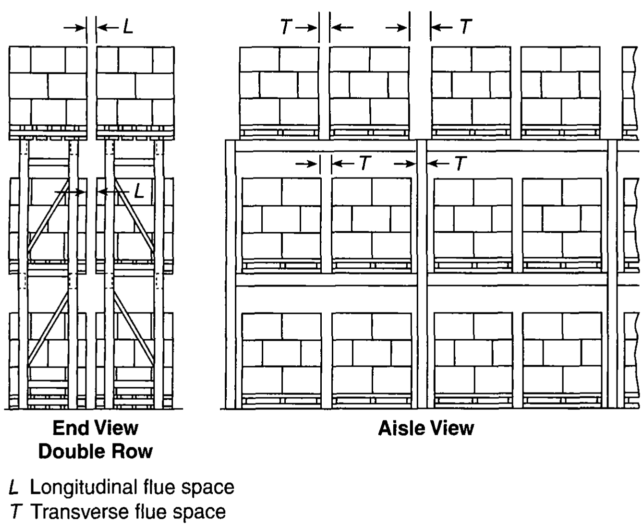


FIGURE A.3.10.8(a) Conventional Pallet Rack.

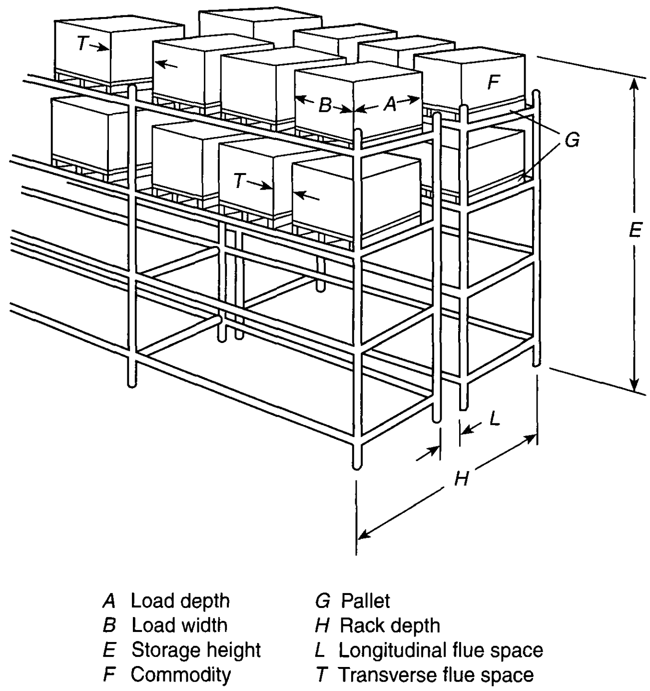


FIGURE A.3.10.8(b) Double-Row Racks Without Solid or Slatted Shelves.

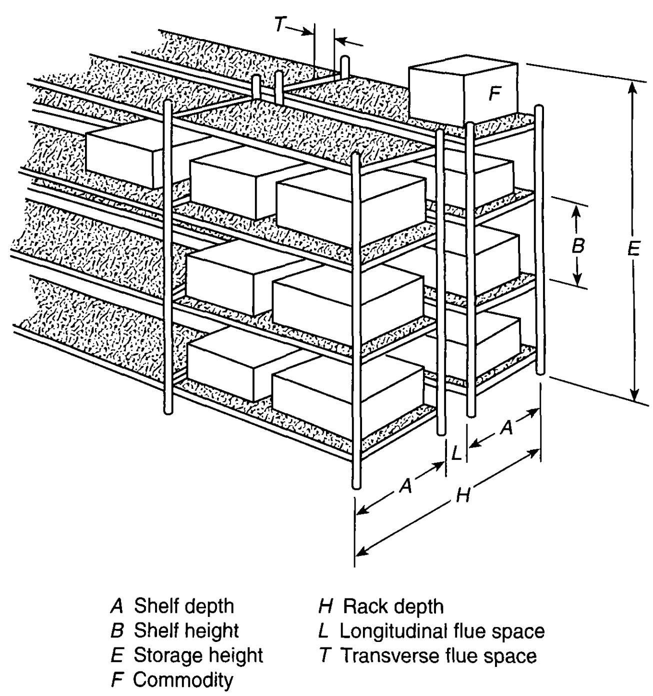


FIGURE A.3.10.8(c) Double-Row Racks with Solid Shelves.

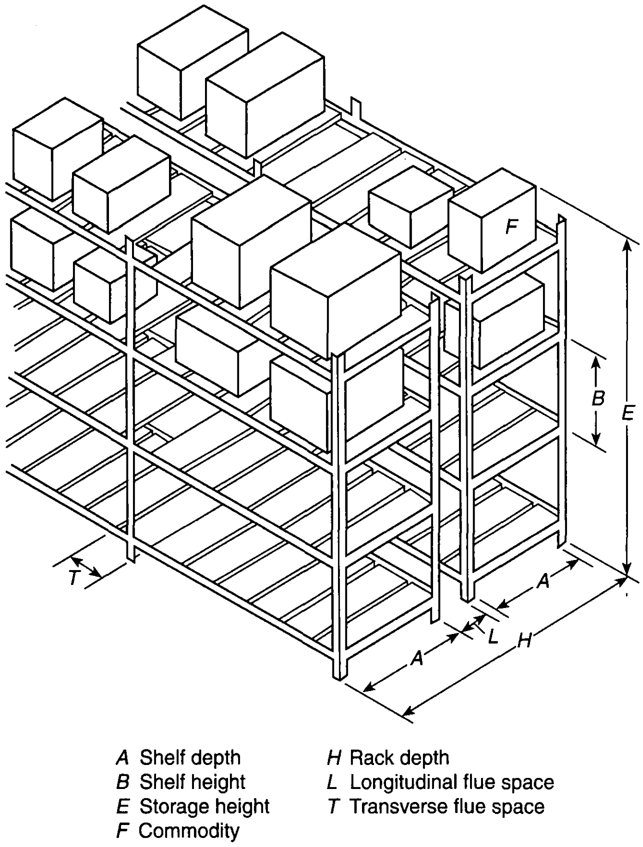


FIGURE A.3.10.8(d) Double-Row Racks with Slatted Shelves.

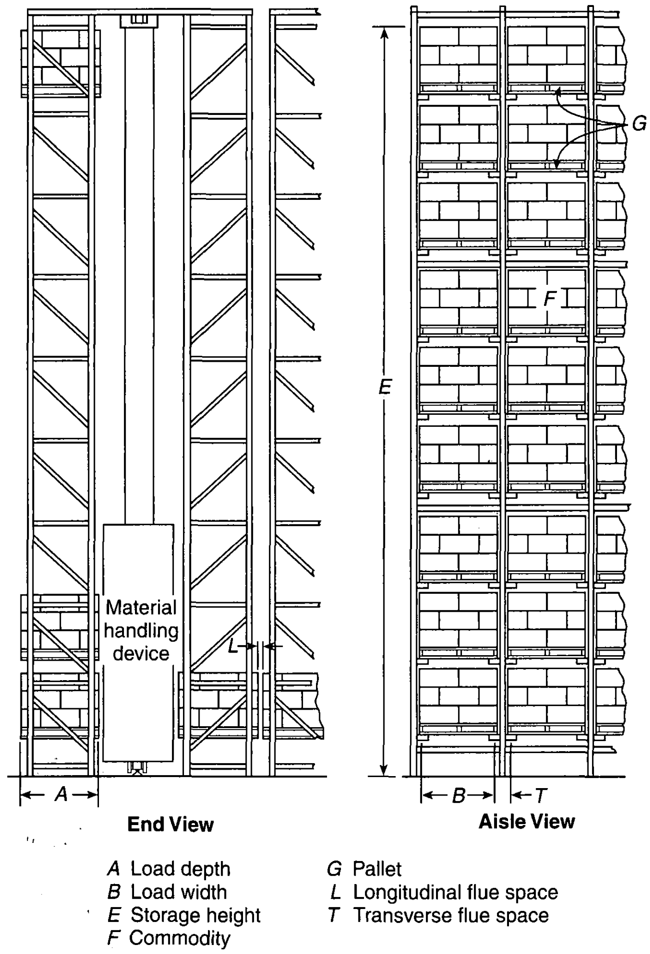


FIGURE A.3.10.8(e) Automatic Storage-Type Rack.

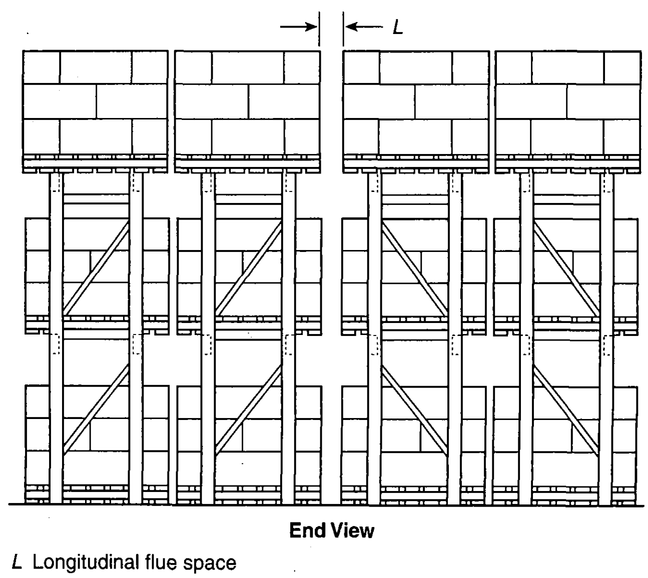
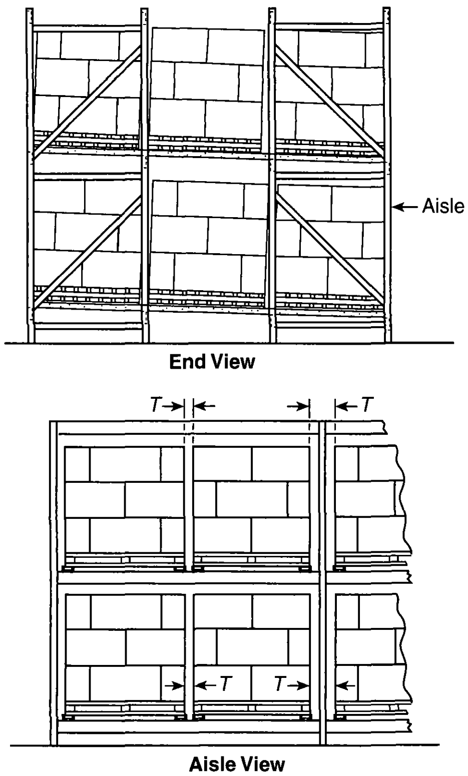
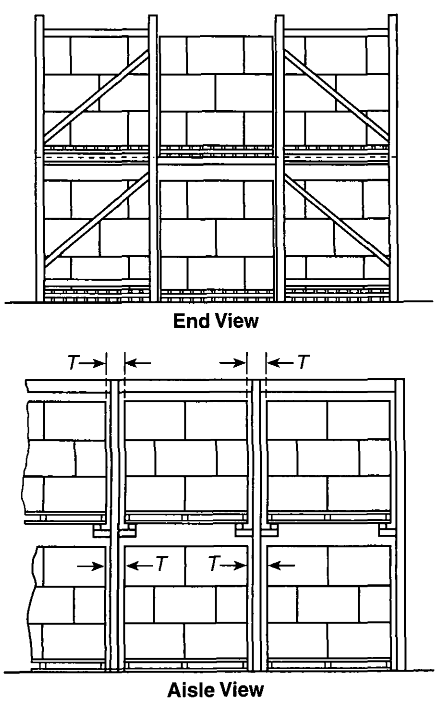


FIGURE A.3.10.8(f) Multiple-Row Rack to Be Served by a Reach Truck.



T Transverse flue space

FIGURE A.3.10.8(g) Flow-Through Pallet Rack.



T Transverse flue space

FIGURE A.3.10.8(h) Drive-In Rack — Two or More Pallets Deep (Fork Truck Drives into the Rack to Deposit and Withdraw Loads in the Depth of the Rack).

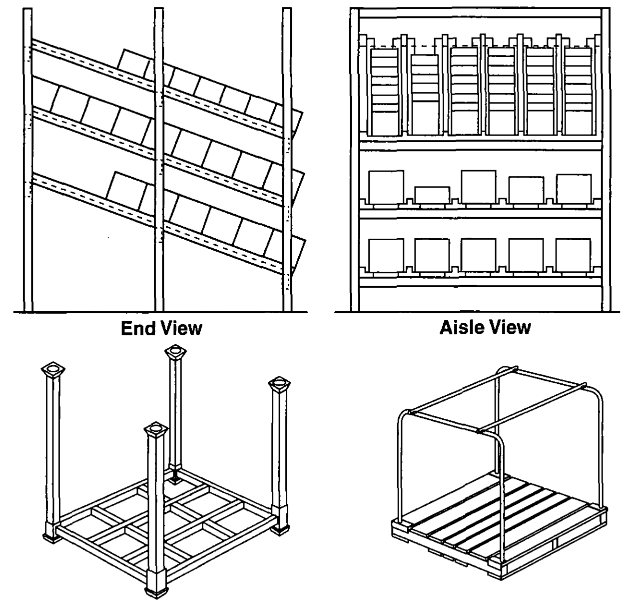


FIGURE A.3.10.8(i) Flow-Through Racks (Top) and Portable Racks (Bottom).

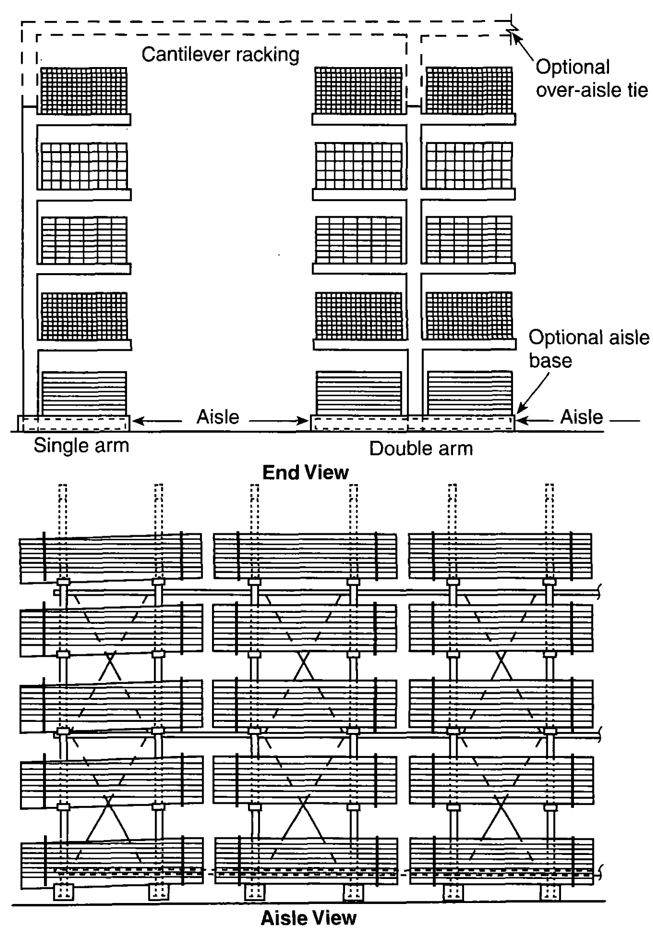


FIGURE A.3.10.8(j) Cantilever Rack.

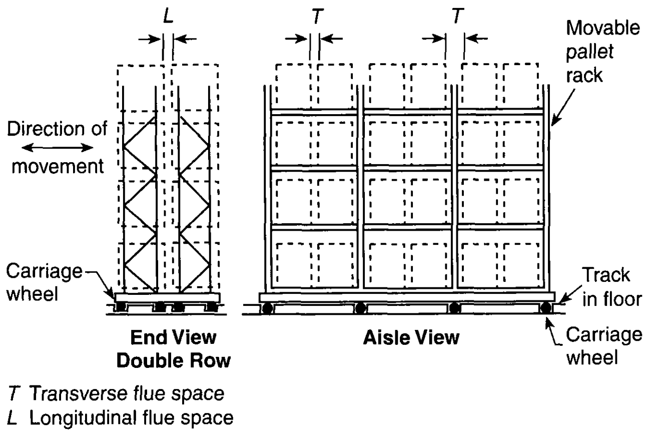


FIGURE A.3.10.8(k) Movable Rack.

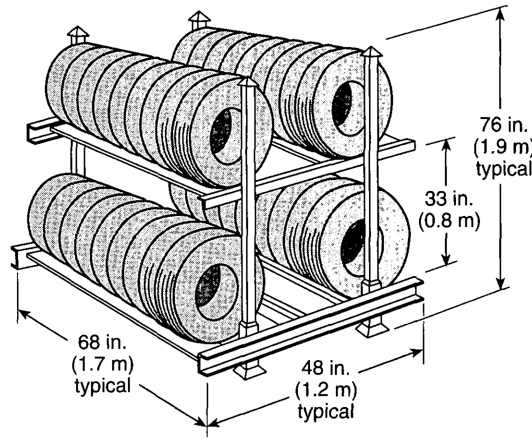


FIGURE A.3.11.9(c) Open Portable Tire Rack.

A.3.11.9 Rubber Tire Rack Illustrations. Figure A.3.11.9(a) through Figure A.3.11.9(g) do not necessarily cover all possible rubber tire storage configurations.

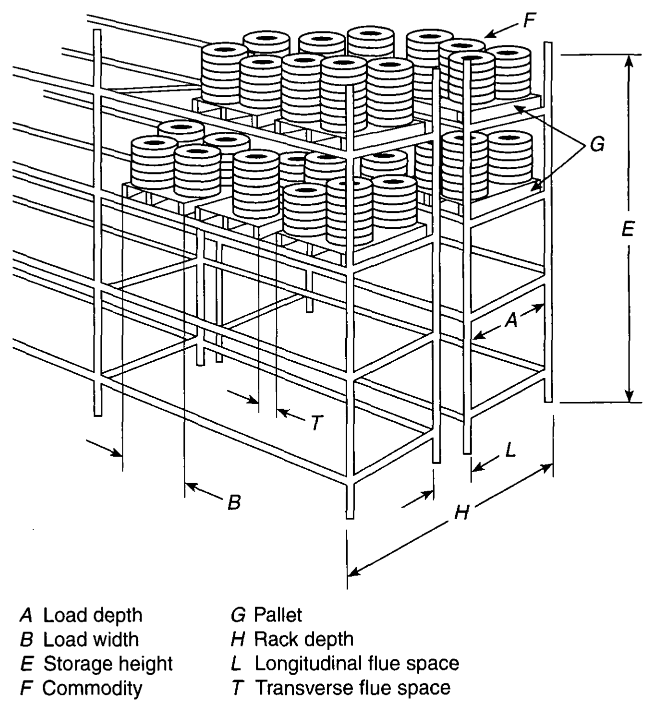


FIGURE A.3.11.9(d) Double-Row Fixed Tire Rack Storage.

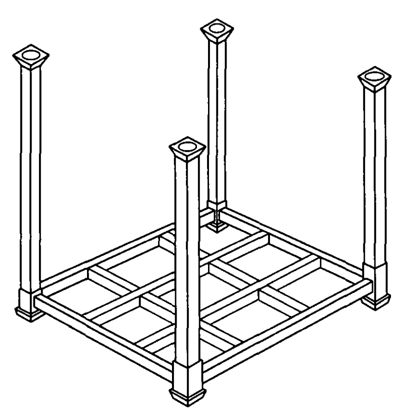


FIGURE A.3.11.9(a) Typical Open Portable Tire Rack Unit.

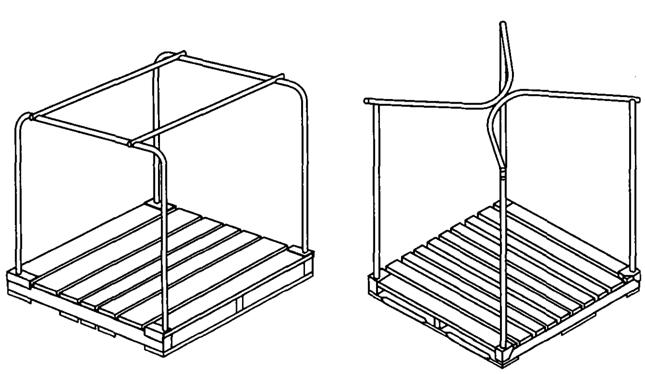


FIGURE A.3.11.9(b) Typical Palletized Portable Tire Rack Units.

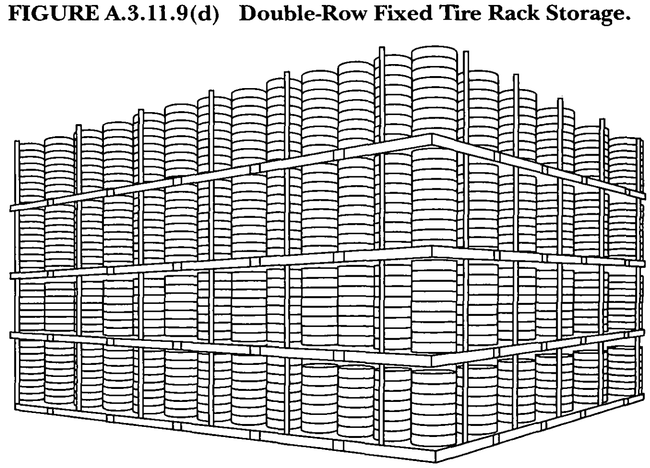


FIGURE A.3.11.9(e) Palletized Portable Tire Rack, On-Side Storage Arrangement (Banded or Unbanded).

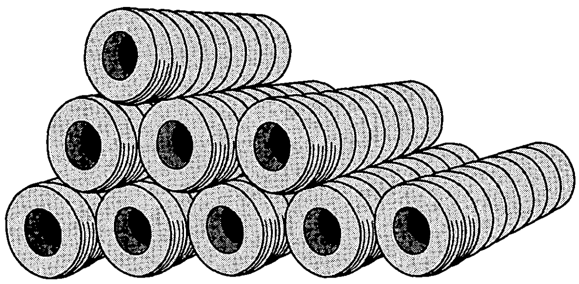


FIGURE A.3.11.9(f) On-Floor Storage; On-Tread, Normally Banded.

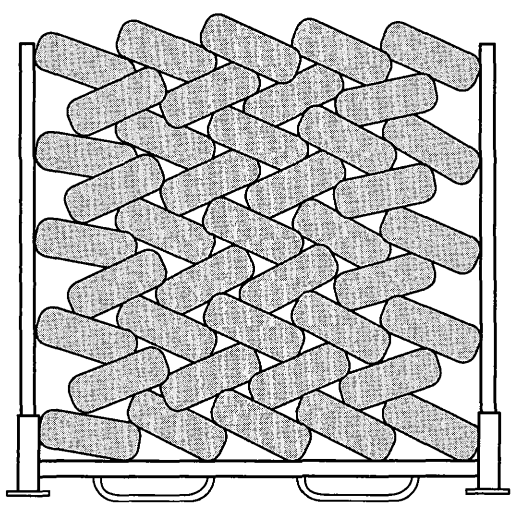


FIGURE A.3.11.9(g) Typical Laced Tire Storage.

A.3.12.1 Baled Cotton. See Table A.3.12.1.

A.3.13.1.3 Standard Array (Paper). The occasional presence of partially used rolls on top of columns of otherwise uniform diameter rolls does not appreciably affect the burning characteristics.

A.3.13.6.3 Wrapped Roll Paper Storage. Rolls that are completely protected with a heavyweight kraft wrapper on both sides and ends are subject to a reduced degree of fire hazard. Standard methods for wrapping and capping rolls are outlined in Figure A.3.13.6.3.

In some cases, rolls are protected with laminated wrappers, using two sheets of heavy kraft with a high-temperature wax laminate between the sheets. Where using this method, the overall weight of wax-laminated wrappers should be based on the basis weight per 1000 ft^2 (92.9 m^2) of the outer sheet only, rather than on the combined basis weight of the outer and inner laminated wrapper sheets. A properly applied wrapper can have the effect of changing the class of a given paper to essentially that of the wrapper material. The effect of applying a wrapper to tissue has not been determined by test.

A.3.13.7 Roll Paper Storage Height. The size of rolls and limitations of mechanical handling equipment should be considered in determining maximum storage height.

A.3.14.4 Heat-Sensitive Material. The backbone of the fire protection philosophy for U.S. flagged vessels and passenger vessels that trade internationally is limiting a fire to the compartment of origin by passive means. Materials that do not withstand a 1-hour fire exposure when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, are considered "heat sensitive." *(See Figure A.3.14.4.)*

A.3.14.8 Marine System. Some types of sprinkler systems can closely resemble marine systems, such as a system installed on a floating structure that has a permanent water supply connection to a public main. For these types of systems, judgment should be used in determining if certain aspects of Chapter 17 are applicable.

A.3.14.9 Marine Thermal Barrier. A marine thermal barrier is typically referred to as a B-15 boundary.

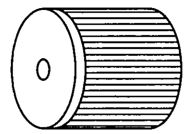
A.5.1 Occupancy examples in the listings as shown in the various hazard classifications are intended to represent the norm for those occupancy types. Unusual or abnormal fuel loadings or combustible characteristics and susceptibility for changes in these characteristics, for a particular occupancy, are considerations that should be weighed in the selection and classification.

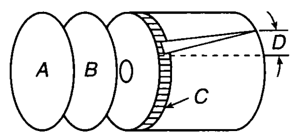
The light hazard classification is intended to encompass residential occupancies; however, this is not intended to preclude the use of listed residential sprinklers in residential occupancies or residential portions of other occupancies.

Table A.3.12.1 Typical Cotton Bale Types and Approximate Sizes

	Dimensions		Average Weight		Volume		Density	
Bale Type	**in.**	**mm**	**lb**	**kg**	**ft^3**	**m^3**	**lb/ft^3**	**kg/m^3**
Gin, flat	55 × 45 × 28	1397 × 1143 × 711	500	226.8	40.1	1.13	12.5	201
Modified gin, flat	55 × 45 × 24	1397 × 1143 × 610	500	226.8	34.4	0.97	14.5	234
Compressed, standard	57 × 29 × 23	1448 × 736 × 584	500	226.8	22.0	0.62	22.7	366
Gin, standard	55 × 31 × 21	1397 × 787 × 533	500	226.9	20.7	0.58	24.2	391
Compressed, universal	58 × 25 × 21	1475 × 635 × 533	500	226.8	17.6	0.50	28.4	454
Gin, universal	55 × 26 × 21	1397 × 660 × 533	500	226.8	17.4	0.49	28.7	463
Compressed, high density	58 × 22 × 21	1473 × 559 × 533	500	226.8	15.5	0.44	32.2	515

Wrapper	
Exterior wrapper Body wrapper	General term for protective wrapping of sides and ends on roll.
Body wrap	
Sleeve wrap Wrap — do not cap	Wrapper placed around circumference of roll. No heads or caps needed.





Heads	
Headers	Protection applied to the ends of the rolls (*A* and *B*). Heads do not lap over the end of the roll.
Inside heads	Protection applied to the ends of the rolls next to the roll itself (*B*). The wrapper of the rolls is crimped down over these heads.
Outside heads	Protection applied to the ends of the rolls on the outside (*A*). This head is applied after the wrapper is crimped.
Edge protectors	
Edge bands	Refers to extra padding to prevent damage to roll edges (*C*).
Overwrap	The distance the body wrap or wrapper overlaps itself (*D*).
Roll cap	A protective cover placed over the end of a roll. Edges of cap lap over the end of the roll and are secured to the sides of the roll.

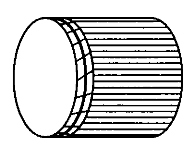
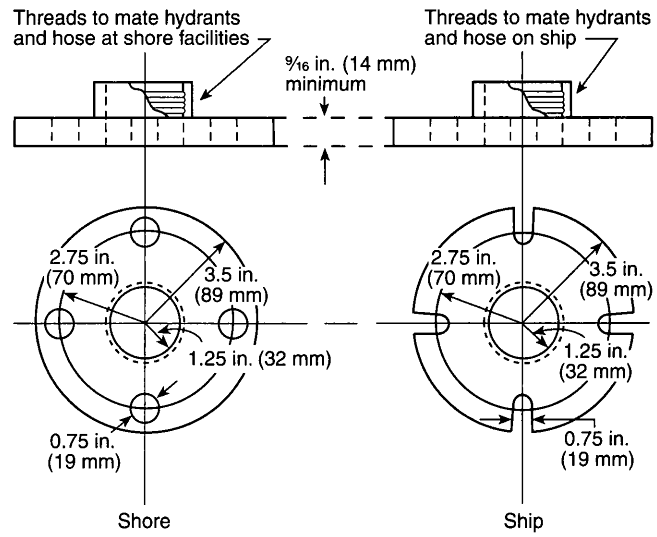


FIGURE A.3.13.6.3 Wrapping and Capping Terms and Methods.

A.5.2 Light hazard occupancies include occupancies having uses and conditions similar to the following:

Churches
Clubs
Eaves and overhangs, if of combustible construction with no combustibles beneath
Educational
Hospitals
Institutional
Libraries, except large stack rooms
Museums
Nursing or convalescent homes
Offices, including data processing
Residential
Restaurant seating areas
Theaters and auditoriums, excluding stages and prosceniums
Unused attics

International Shore Connection



Material: Any suitable for 150 psi (10.3 bar) service (shore)
Flange surface: Flat face
Gasket material: Any suitable for 150 psi (10.3 bar) service
Bolts: Four 5⁄8-in. (16-mm) minimum diameter, 2-in. (51-mm) long, threaded to within 1 in. (25.4 mm) of bolt head
Nuts: Four, to fit bolts
Washers: Four, to fit bolts

Material: Brass or bronze suitable for 150 psi (10.3 bar) service (ship)

FIGURE A.3.14.4 International Shore Fire Connection.

A.5.3.1 Ordinary hazard occupancies (Group 1) include occupancies having uses and conditions similar to the following:

Automobile parking and showrooms
Bakeries
Beverage manufacturing
Canneries
Dairy products manufacturing and processing
Electronic plants
Glass and glass products manufacturing
Laundries
Restaurant service areas

A.5.3.2 Ordinary hazard occupancies (Group 2) include occupancies having uses and conditions similar to the following:

Cereal mills
Chemical plants — ordinary
Confectionery products
Distilleries
Dry cleaners
Feed mills
Horse stables
Leather goods manufacturing
Libraries — large stack room areas
Machine shops
Metal working
Mercantile
Paper and pulp mills

Paper process plants
Piers and wharves
Post offices
Printing and publishing
Repair garages
Resin application area
Stages
Textile manufacturing
Tire manufacturing
Tobacco products manufacturing
Wood machining
Wood product assembly

A.5.4.1 Extra hazard occupancies (Group 1) include occupancies having uses and conditions similar to the following:

Aircraft hangars (except as governed by NFPA 409, *Standard on Aircraft Hangars*)
Combustible hydraulic fluid use areas
Die casting
Metal extruding
Plywood and particle board manufacturing
Printing [using inks having flash points below 100°F (38°C)]
Rubber reclaiming, compounding, drying, milling, vulcanizing
Saw mills
Textile picking, opening, blending, garnetting, or carding, combining of cotton, synthetics, wool shoddy, or burlap
Upholstering with plastic foams

A.5.4.2 Extra hazard occupancies (Group 2) include occupancies having uses and conditions similar to the following:

Asphalt saturating
Flammable liquids spraying
Flow coating
Manufactured home or modular building assemblies (where finished enclosure is present and has combustible interiors)
Open oil quenching
Plastics processing
Solvent cleaning
Varnish and paint dipping

A.5.5 Other NFPA standards contain design criteria for fire control or fire suppression *(see Section 5.5 and Chapter 2)*. While these can form the basis of design criteria, this standard describes the methods of design, installation, fabrication, calculation, and evaluation of water supplies that should be used for the specific design of the system.

Other NFPA standards contain sprinkler system design criteria for fire control or suppression of specific hazards. This information has been either referenced or copied into Chapter 13 using NFPA's extract policy.

A.5.6 Specification of the type, amount, and arrangement of combustibles for any commodity classification is essentially an attempt to define the potential fire severity, based on its burning characteristics, so the fire can be successfully controlled by the prescribed sprinkler protection for the commodity class. In actual storage situations, however, many storage arrays do not fit precisely into one of the fundamental classifications; therefore, the user needs to make judgments after comparing each classification to the existing storage conditions. Storage arrays consist of thousands of products, which make it impossible to specify all the acceptable variations for any class. As an alternative, a variety of common products are classified in this appendix based on judgment, loss experience, and fire test results.

Table A.5.6 provides examples of commodities not addressed by the classifications in Section 5.6.

Table A.5.6.3 is an alphabetized list of commodities with corresponding classifications.

Table A.5.6.3.1 through Table A.5.6.3.4 and Table A.5.6.4.1 provide examples of commodities within a specific class.

Table A.5.6 Examples of Commodities Not Addressed by the Classifications in Section 5.6

Boxes, Crates
- Empty, wood slatted
Lighters (butane)
- Loose in large containers (Level 3 aerosol)

*Should be treated as idle pallets.

A.5.6.1.1 Commodity classification is governed by the types and amounts of materials (e.g., metal, paper, wood, plastics) that are a part of a product and its primary packaging. However, in a storage or warehousing situation, classification is also affected by such factors as the primary storage or shipping container material, the amount of air space, and the location of the more hazardous materials within the container. For example, a Group A plastic product enclosed in a five- or six-sided metal container can be considered Class II, while a ceramic product heavily wrapped in tissue paper and placed in a corrugated carton could be Class III.

A.5.6.3 See Table A.5.6.3.

Table A.5.6.3 Alphabetized Listing of Commodity Classes

Commodity	Commodity Class
Aerosols	
Cartoned or uncartoned	
- Level 1	Class III
Alcoholic Beverages	
Cartoned or uncartoned	
- Up to 20 percent alcohol in metal, glass, or ceramic containers	Class I
- Up to 20 percent alcohol in wood containers	Class II
Ammunition	
Small arms, shotgun	
- Packaged, cartoned	Class IV
Appliances, Major (e.g., stoves, refrigerators)	
- Not packaged, no appreciable plastic exterior trim	Class I
- Corrugated, cartoned (no appreciable plastic trim)	Class II
Baked Goods	
Cookies, cakes, pies	
- Frozen, packaged in cartons[1]	Class II
- Packaged, in cartons	Class III

Table A.5.6.3 *Continued*

Commodity	Commodity Class
Batteries	
Dry cells (nonlithium or similar exotic metals)	
- Packaged in cartons	Class I
- Blister-packed in cartons	Class II
Automobile	
- Filled[2]	Class I
Truck or larger	
- Empty or filled[2]	Group A plastics
Beans	
Dried	
- Packaged, cartoned	Class III
Bottles, Jars	
Empty, cartoned	
- Glass	Class I
- Plastic PET (polyethylene terephthalate)	Class IV
Filled noncombustible powders	
- Plastic PET	Class II
- Glass, cartoned	Class I
- Plastic, cartoned [less than 1 gal (3.8 L)]	Class IV
- Plastic, uncartoned (other than PET), any size	Group A plastics
- Plastic, cartoned or exposed [greater than 1 gal (3.8 L)]	Group A plastics
- Plastic, solid plastic crates	Group A plastics
- Plastic, open plastic crates	Group A plastics
Filled noncombustible liquids	
- Glass, cartoned	Class I
- Plastic, cartoned [less than 5 gal (18.9 L)]	Class I
- Plastic, open or solid plastic crates[3]	Group A plastics
- Plastic, PET	Class I
Boxes, Crates	
- Empty, wood, solid walls	Class II
- Empty, wood, slatted[4]	Outside of scope
Bread	
Wrapped cartoned	Class III
Butter	
Whipped spread	Class III
Candles	
Packaged, cartoned	
- Treat as expanded plastic	Group A plastics
Candy	
Packaged, cartoned	Class III
Canned Foods	
In ordinary cartons	Class I
Cans	
Metal	
- Empty	Class I
Carpet Tiles	
Cartoned	Group A plastics
Cartons	
Corrugated	
- Unassembled (neat piles)	Class III
- Partially assembled	Class IV
Wax coated, single walled	Group A plastics
Cement	
Bagged	Class I
Cereals	
Packaged, cartoned	Class III

Table A.5.6.3 *Continued*

Commodity	Commodity Class
Charcoal	
Bagged	
- Standard	Class III
Cheese	
- Packaged, cartoned	Class III
- Wheels, cartoned	Class III
Chewing Gum	
Packaged, cartoned	Class III
Chocolate	
Packaged, cartoned	Class III
Cloth	
Cartoned and not cartoned	
- Natural fiber, viscose	Class III
- Synthetic[5]	Class IV
Cocoa Products	
Packaged, cartoned	Class III
Coffee	
- Canned, cartoned	Class I
- Packaged, cartoned	Class III
Coffee Beans	
Bagged	Class III
Cotton	
Packaged, cartoned	Class III
Diapers	
- Cotton, linen	Class III
- Disposable with plastics and nonwoven fabric (in cartons)	Class IV
- Disposable with plastics and nonwoven fabric (uncartoned), plastic wrapped	Group A plastics
Dried Foods	
Packaged, cartoned	Class III
Fertilizers	
Bagged	
- Phosphates	Class I
- Nitrates	Class II
Fiberglass Insulation	
- Paper-backed rolls, bagged or unbagged	Class IV
File Cabinets	
Metal	
- Cardboard box or shroud	Class I
Fish or Fish Products	
Frozen	
- Nonwaxed, nonplastic packaging	Class I
- Waxed-paper containers, cartoned	Class II
- Boxed or barreled	Class II
- Plastic trays, cartoned	Class III
Canned	
- Cartoned	Class I
Frozen Foods	
Nonwaxed, nonplastic packaging	Class I
- Waxed-paper containers, cartoned	Class II
- Plastic trays	Class III
Fruit	
Fresh	
- Nonplastic trays or containers	Class I
- With wood spacers	Class I
Furniture	
Wood	
- No plastic coverings or foam plastic cushioning	Class III
- With plastic coverings	Class IV
- With foam plastic cushioning	Group A plastics

Table A.5.6.3 *Continued*

Commodity	Commodity Class
Grains — Packaged in Cartons	
- Barley	Class III
- Rice	Class III
- Oats	Class III
Ice Cream	Class I
Leather Goods	Class III
Leather Hides	
Baled	Class II
Light Fixtures	
Nonplastic	
- Cartoned	Class II
Lighters	
Butane	
- Blister-packed, cartoned	Group A plastics
- Loose in large containers (Level 3 aerosol)	Outside of scope
Liquor	
100 proof or less, 1 gal (3.8 L) or less, cartoned	
- Glass (palletized)[6]	Class IV
- Plastic bottles	Class IV
Marble	
Artificial sinks, countertops	
- Cartoned, crated	Class II
Margarine	
- Up to 50 percent oil (in paper or plastic containers)	Class III
- Between 50 percent and 80 percent oil (in any packaging)	Group A plastics
Matches	
Packaged, cartoned	
- Paper	Class IV
- Wood	Group A plastics
Mattresses	
- Standard (box spring)	Class III
- Foam (in finished form)	Group A plastics
Meat, Meat Products	
- Bulk	Class I
- Canned, cartoned	Class I
- Frozen, nonwaxed, nonplastic containers	Class I
- Frozen, waxed-paper containers	Class II
- Frozen, expanded plastic trays	Class II
Metal Desks	
- With plastic tops and trim	Class I
Milk	
- Nonwaxed-paper containers	Class I
- Waxed-paper containers	Class I
- Plastic containers	Class I
- Containers in plastic crates	Group A plastics
Motors	
- Electric	Class I
Nail Polish	
- 1-oz to 2-oz (29.6-ml to 59.1-ml) glass, cartoned	Class IV
- 1-oz to 2-oz (29.6-ml to 59.1-ml) plastic bottles, cartoned	Group A plastics
Nuts	
- Canned, cartoned	Class I
- Packaged, cartoned	Class III
- Bagged	Class III
Paints	
Friction-top cans, cartoned	

Table A.5.6.3 *Continued*

Commodity	Commodity Class
- Water-based (latex)	Class I
- Oil-based	Class IV
Paper Products	
- Books, magazines, stationery, plastic-coated paper food containers, newspapers, cardboard games, or cartoned tissue products	Class III
- Tissue products, uncartoned and plastic wrapped	Group A plastics
Paper, Rolled	
In racks or on side	Class III
- Medium- or heavyweight	
In racks	Class IV
- Lightweight	
Paper, Waxed	
Packaged in cartons	Class IV
Pharmaceuticals	
Pills, powders	
- Glass bottles, cartoned	Class II
- Plastic bottles, cartoned	Class IV
Nonflammable liquids	
- Glass bottles, cartoned	Class II
Photographic Film	
- Motion picture or bulk rolls of film in polycarbonate, polyethylene, or metal cans; polyethylene bagged in cardboard boxes	Class II
- 35-mm in metal film cartridges in polyethylene cans in cardboard boxes	Class III
- Paper, in sheets, bagged in polyethylene, in cardboard boxes	Class III
- Rolls in polycarbonate plastic cassettes, bulk wrapped in cardboard boxes	Class IV
Plastic Containers (except PET)	
- Noncombustible liquids or semiliquids in plastic containers less than 5 gal (18.9 L) capacity	Class I
- Noncombustible liquids or semiliquids (such as ketchup) in plastic containers with nominal wall thickness of ¼ in. (6.4 mm) or less and larger than 5 gal (18.9) capacity	Class II
- Noncombustible liquids or semiliquids (such as ketchup) in plastic containers with nominal wall thickness greater than ¼ in. (6.4 mm) and larger than 5 gal (18.9 L) capacity	Group A plastics
Polyurethane	
- Cartoned or uncartoned expanded	Group A plastics
Poultry Products	
- Canned, cartoned	Class I
- Frozen, nonwaxed, nonplastic containers	Class I
- Frozen (on paper or expanded plastic trays)	Class II
Powders	
Ordinary combustibles — free flowing	
- In paper bags (e.g., flour, sugar)	Class II
PVA (polyvinyl alcohol) Resins	
PVC (polyvinyl chloride)	

Table A.5.6.3 *Continued*

Commodity	Commodity Class
- Flexible (e.g., cable jackets, plasticized sheets)	Class III
- Rigid (e.g., pipe, pipe fittings)	Class III
- Bagged resins	Class III
Rags	
Baled	
- Natural fibers	Class III
- Synthetic fibers	Class IV
Rubber	
- Natural, blocks in cartons	Class IV
- Synthetic	Group A plastics
Salt	
- Bagged	Class I
- Packaged, cartoned	Class II
Shingles	
- Asphalt-coated fiberglass	Class III
- Asphalt-impregnated felt	Class IV
Shock Absorbers	
- Metal dust cover	Class II
- Plastic dust cover	Class III
Signatures	
Books, magazines	
- Solid array on pallet	Class II
Skis	
- Wood	Class III
- Foam core	Class IV
Stuffed Toys	
Foam or synthetic	Group A plastics
Syrup	
- Drummed (metal containers)	Class I
- Barreled, wood	Class II
Textiles	
Natural fiber clothing or textile products	Class III
Synthetics (except rayon and nylon) — 50/50 blend or less	
- Thread, yarn on wood or paper spools	Class III
- Fabrics	Class III
- Thread, yarn on plastic spools	Class IV
- Baled fiber	Group A plastics
Synthetics (except rayon and nylon) — greater than 50/50 blend	
- Thread, yarn on wood or paper spools	Class IV
- Fabrics	Class IV
- Baled fiber	Group A plastics
- Thread, yarn on plastic spools	Group A plastics
Rayon and nylon	
- Baled fiber	Class IV
- Thread, yarn on wood or paper spools	Class IV
- Fabrics	Class IV
- Thread, yarn on plastic spools	Group A plastics
Tobacco Products	
In paperboard cartons	Class III
Transformers	
Dry and oil filled	Class I
Vinyl-Coated Fabric	
Cartoned	Group A plastics
Vinyl Floor Coverings	
- Tiles in cartons	Class IV

Table A.5.6.3 *Continued*

Commodity	Commodity Class
- Rolled	Group A plastics
Wax-Coated Paper	
Cups, plates	
- Boxed or packaged inside cartons (emphasis on packaging)	Class IV
- Loose inside large cartons	Group A plastics
Wax	
Paraffin/petroleum wax, blocks, cartoned	Group A plastics
Wire	
- Bare wire on metal spools on wood skids	Class I
- Bare wire on wood or cardboard spools on wood skids	Class II
- Bare wire on metal, wood, or cardboard spools in cardboard boxes on wood skids	Class II
- Single- or multiple-layer PVC-covered wire on metal spools on wood skids	Class II
- Insulated (PVC) cable on large wood or metal spools on wood skids	Class II
- Bare wire on plastic spools in cardboard boxes on wood skids	Class IV
- Single- or multiple-layer PVC-covered wire on plastic spools in cardboard boxes on wood skids	Class IV
- Single, multiple, or power cables (PVC) on large plastic spools	Class IV
- Bulk storage of empty plastic spools	Group A plastics
Wood Products	
- Solid piles — lumber, plywood, particleboard, pressboard (smooth ends and edges)	Class II
- Spools (empty)	Class III
- Toothpicks, clothespins, hangers in cartons	Class III
- Doors, windows, wood cabinets, and furniture	Class III
- Patterns	Class IV

[1] The product is presumed to be in a plastic-coated package in a corrugated carton. If packaged in a metal foil, it can be considered Class I.

[2] Most batteries have a polypropylene case and, if stored empty, should be treated as a Group A plastic. Truck batteries, even where filled, should be considered a Group A plastic because of their thicker walls.

[3] As the openings in plastic crates become larger, the product behaves more like a Class III commodity. Conversely, as the openings become smaller, the product behaves more like a plastic.

[4] These items should be treated as idle pallets.

[5] Tests clearly indicate that a synthetic or synthetic blend is considered greater than Class III.

[6] When liquor is stored in glass containers in racks, it should be considered a Class III commodity; where it is palletized, it should be considered a Class IV commodity.

A.5.6.3.1 See Table A.5.6.3.1.

Table A.5.6.3.1 Examples of Class I Commodities

Alcoholic Beverages
Cartoned or uncartoned
- Up to 20 percent alcohol in metal, glass, or ceramic containers

Appliances, Major (e.g., stoves, refrigerators)
- Not packaged, no appreciable plastic exterior trim

Batteries
Dry cells (nonlithium or similar exotic metals)
- Packaged in cartons

Automobile
- Filled*

Bottles, Jars
Empty, cartoned
- Glass

Filled noncombustible liquids
- Glass, cartoned
- Plastic, cartoned [less than 5 gal (18.9 L)]
- Plastic, PET

Filled noncombustible powders
- Glass, cartoned

Canned Foods
In ordinary cartons
Cans
Metal
- Empty

Cement
Bagged
Coffee
Canned, cartoned
Fertilizers
Bagged
- Phosphates

File Cabinets
Metal
- Cardboard box or shroud

Fish or Fish Products
Frozen
- Nonwaxed, nonplastic packaging

Canned
- Cartoned

Frozen Foods
Nonwaxed, nonplastic packaging
Fruit
Fresh
- Nonplastic trays or containers
- With wood spacers

Ice Cream
Meat, Meat Products
- Bulk
- Canned, cartoned
- Frozen, nonwaxed, nonplastic containers

Metal Desks
- With plastic tops and trim

Milk
- Nonwaxed-paper containers
- Waxed-paper containers
- Plastic containers

Motors
- Electric

Nuts
- Canned, cartoned

Paints
Friction-top cans, cartoned
- Water-based (latex)

Plastic Containers
- Noncombustible liquids or semiliquids in plastic containers less than 5 gal (18.9 L) capacity

Poultry Products
- Canned, cartoned
- Frozen, nonwaxed, nonplastic containers

Salt
Bagged
Syrup
Drummed (metal containers)
Transformers
Dry and oil filled
Wire
Bare wire on metal spools on wood skids

*Most batteries have a polypropylene case and, if stored empty, should be treated as a Group A plastic. Truck batteries, even where filled, should be considered a Group A plastic because of their thicker walls.

A.5.6.3.2 See Table A.5.6.3.2.

Table A.5.6.3.2 Examples of Class II Commodities

Alcoholic Beverages
Up to 20 percent alcohol in wood containers
Appliances, Major (e.g., stoves)
Corrugated, cartoned (no appreciable plastic trim)
Baked Goods
Cookies, cakes, pies
- Frozen, packaged in cartons*

Batteries
Dry cells (nonlithium or similar exotic metals) in blister pack in cartons
Bottles, Jars
Filled noncombustible powders
- Plastic PET

Boxes, Crates
Empty, wood, solid walls
Fertilizers
Bagged
- Nitrates

Fish or Fish Products
Frozen
- Waxed-paper containers, cartoned
- Boxed or barreled

Frozen Foods
Waxed-paper containers, cartoned
Leather Hides
Baled
Light Fixtures
Nonplastic
- Cartoned

Marble
Artificial sinks, countertops
- Cartoned, crated

Meat, Meat Products
- Frozen, waxed-paper containers
- Frozen, expanded plastic trays

Pharmaceuticals
Pills, powders
- Glass bottles, cartoned

Nonflammable liquids
- Glass bottles, cartoned

Table A.5.6.3.2 *Continued*

Photographic Film
- Motion picture or bulk rolls of film in polycarbonate, polyethylene, or metal cans; polyethylene bagged in cardboard boxes
Plastic Containers
Noncombustible liquids or semiliquids (such as ketchup) in plastic containers with nominal wall thickness of ¼ in. (6.4 mm) or less and larger than 5 gal (18.9 L) capacity
Poultry Products
Frozen (on paper or expanded plastic trays)
Powders (ordinary combustibles — free flowing)
In paper bags (e.g., flour, sugar)
Salt
Packaged, cartoned
Shock Absorbers
Metal dust cover
Signatures
Book, magazines
- Solid array on pallet
Syrup
Barreled, wood
Wire
- Bare wire on wood or cardboard spools on wood skids
- Bare wire on metal, wood, or cardboard spools in cardboard boxes on wood skids
- Single- or multiple-layer PVC-covered wire on metal spools on wood skids
- Insulated (PVC) cable on large wood or metal spools on wood skids
Wood Products
Solid piles
- Lumber, plywood, particle board, pressboard (smooth ends and edges)

*The product is in a plastic-coated package in a corrugated carton. If packaged in a metal foil, it can be considered Class I.

A.5.6.3.3 See Table A.5.6.3.3.

Table A.5.6.3.3 Examples of Class III Commodities

Aerosols
Cartoned or uncartoned
- Level 1
Baked Goods
Cookies, cakes, pies
- Packaged, in cartons
Beans
Dried
- Packaged, cartoned
Bread
Wrapped, cartoned
Butter
Whipped spread
Candy
Packaged, cartoned
Cartons
Corrugated
- Unassembled (neat piles)
Cereals
Packaged, cartoned
Charcoal
Bagged
- Standard
Cheese
- Packaged, cartoned
- Wheels, cartoned
Chewing Gum
Packaged, cartoned
Chocolate
Packaged, cartoned
Cloth
Cartoned and not cartoned
- Natural fiber, viscose
Cocoa Products
Packaged, cartoned
Coffee
Packaged, cartoned
Coffee Beans
Bagged
Cotton
Packaged, cartoned
Diapers
Cotton, linen
Dried Foods
Packaged, cartoned
Fish or Fish Products
Frozen
- Plastic trays, cartoned
Frozen Foods
Plastic trays
Furniture
Wood
- No plastic coverings or foam plastic cushioning
Grains — Packaged in Cartons
- Barley
- Rice
- Oats
Margarine
Up to 50 percent oil (in paper or plastic containers)
Mattresses
Standard (box spring)
Nuts
- Packaged, cartoned
- Bagged
Paper Products
Books, magazines, stationery, plastic-coated paper food containers, newspapers, cardboard games, cartoned tissue products
Paper, Rolled
In racks or on side
- Medium or heavyweight
Photographic Film
- 35-mm in metal film cartridges in polyethylene cans in cardboard boxes
- Paper, in sheets, bagged in polyethylene, in cardboard boxes
PVC (polyvinyl chloride)
- Flexible (e.g., cable jackets, plasticized sheets)
- Rigid (e.g., pipe, pipe fittings)
- Bagged resins

Table A.5.6.3.3 ***Continued***

Rags
Baled
- Natural fibers
Shingles
Asphalt-coated fiberglass
Shock Absorbers
Plastic dust cover
Skis
Wood
Textiles
Natural fiber clothing or textile products
Synthetics (except rayon and nylon) — 50/50 blend or less
- Thread, yarn on wood or paper spools
- Fabrics
Tobacco Products
In paperboard cartons
Wood Products
- Spools (empty)
- Toothpicks, clothespins, hangers in cartons
- Doors, windows, wood cabinets, and furniture

A.5.6.3.4 See Table A.5.6.3.4.

Table A.5.6.3.4 Examples of Class IV Commodities

Ammunition
Small arms, shotgun
- Packaged, cartoned
Bottles, Jars
Empty, cartoned
- Plastic PET (polyethylene terephthalate)
Filled noncombustible powders
- Plastic, cartoned [less than 1 gal (3.8 L)]
Cartons
Corrugated
- Partially assembled
Cloth
Cartoned and not cartoned
- Synthetic[1]
Diapers
Disposable with plastics and nonwoven fabric (in cartons)
Fiberglass Insulation
- Paper-backed rolls, bagged or unbagged
Furniture
Wood
- With plastic coverings
Liquor
100 proof or less, 1 gal (3.8 L) or less, cartoned
- Glass (palletized)[2]
- Plastic bottles
Matches
Packaged, cartoned
- Paper
Nail Polish
1-oz to 2-oz (29.6-ml to 59.1-ml) glass, cartoned
Paints
Friction-top cans, cartoned
- Oil based
Paper, Rolled
In racks
- Lightweight
Paper, Waxed
Packaged in cartons
Pharmaceuticals
Pills, powders
- Plastic bottles, cartoned
Photographic Film
- Rolls in polycarbonate plastic cassettes, bulk wrapped in cardboard boxes
PVA (polyvinyl alcohol) Resins
Bagged
Rags
Baled
- Synthetic fibers
Rubber
Natural, blocks in cartons
Shingles
Asphalt-impregnated felt
Skis
Foam core
Textiles
Synthetics (except rayon and nylon) — 50/50 blend or less
- Thread, yarn on plastic spools
Synthetics (except rayon and nylon) — greater than 50/50 blend
- Thread, yarn on wood or paper spools
- Fabrics
Rayon and nylon
- Baled fiber
- Thread, yarn on wood or paper spools
- Fabrics
Vinyl Floor Coverings
Tiles in cartons
Wax-Coated Paper
Cups, plates
- Boxed or packaged inside cartons (emphasis is on packaging)
Wire
- Bare wire on plastic spools in cardboard boxes on wood skids
- Single- or multiple-layer PVC-covered wire on plastic spools in cardboard boxes on wood skids
- Single, multiple, or power cables (PVC) on large plastic spools
Wood Products
Patterns

[1] Tests clearly indicate that a synthetic or synthetic blend is considered greater than Class III.
[2] Where liquor is stored in glass containers in racks, it should be considered a Class III commodity; where it is palletized, it should be considered a Class IV commodity.

A.5.6.4 The categories listed in 5.6.4.1, 5.6.4.2, and 5.6.4.3 are based on unmodified plastic materials. The use of fire- or flame-retarding modifiers or the physical form of the material could change the classification.

A.5.6.4.1 See Table A.5.6.4.1.

Table A.5.6.4.1 Examples of Group A Plastic Commodities

Batteries
  Truck or larger
  - Empty or filled[1]
Bottles, Jars
  Empty, cartoned
  - Plastic (other than PET), any size
  Filled noncombustible liquids
  - Plastic, open or solid plastic crates[2]
  Filled noncombustible powders
  - Plastic, cartoned or uncartoned [greater than 1 gal (3.8 L)]
  - Plastic, solid plastic crates
  - Plastic, open plastic crates
Candles
  Packaged, cartoned
  - Treat as expanded plastic
Carpet Tiles
  Cartoned
Cartons
  Wax coated, single walled
Diapers
  Disposable with plastics and nonwoven fabric (uncartoned), plastic wrapped
Furniture
  Wood
  - With foam plastic cushioning
Lighters
  Butane
  - Blister-packed, cartoned
Margarine
  Between 50 percent and 80 percent oil (in any packaging)
Matches
  Packaged, cartoned
  - Wood
Mattresses
  Foam (in finished form)
Milk
  Containers in plastic crates
Nail Polish
  1-oz to 2-oz (29.6-ml to 59.1-ml) plastic bottles, cartoned
Paper Products
  Tissue products, uncartoned and plastic wrapped
Plastic Containers
  - Combustible or noncombustible solids in plastic containers and empty plastic containers
  - Noncombustible liquids or semiliquids (such as ketchup) in plastic containers with nominal wall thickness greater than ¼ in. (6.4 mm) and larger than 5 gal (18.9 L) capacity
Polyurethane
  Cartoned or uncartoned expanded
Rubber
  Synthetic
Stuffed Toys
  Foam or synthetic
Textiles
  Synthetics (except rayon and nylon) — 50/50 blend or less
  - Baled fiber
  Synthetics (except rayon and nylon)— greater than 50/50 blend
  - Baled fiber

Table A.5.6.4.1 *Continued*

  - Thread, yarn on plastic spools
  Rayon and nylon
  - Thread, yarn on plastic spools
Vinyl-Coated Fabric
  Cartoned
Vinyl Floor Coverings
  Rolled
Wax-Coated Paper
  Cups, plates
  - Loose inside large cartons
Wax
  Paraffin/petroleum wax, blocks, cartoned
Wire
  Bulk storage of empty plastic spools

[1] Most batteries have a polypropylene case and, if stored empty, should be treated as a Group A plastic. Truck batteries, even where filled, should be considered a Group A plastic because of their thicker walls.
[2] As the openings in plastic crates become larger, the product behaves more like Class III. Conversely, as the openings become smaller, the product makeup behaves more like a plastic.

A.5.6.5 *Paper Classification.* These classifications were derived from a series of large-scale and laboratory-type small-scale fire tests. It is recognized that not all paper in a class burns with exactly the same characteristics.

Paper can be soft or hard, thick or thin, or heavy or light and can also be coated with various materials. The broad range of papers can be classified according to various properties. One important property is basis weight, which is defined as the weight of a sheet of paper of a specified area. Two broad categories are recognized by industry — paper and paperboard. Paperboard normally has a basis weight of 20 lb (9.1 kg) or greater measured on a 1000-ft^2 (92.9-m^2) sheet. Stock with a basis weight less than 20 lb/1000 ft^2 (9.1 kg/92.9 m^2) is normally categorized as paper. The basis weight of paper is usually measured on a 3000-ft^2 (278.7-m^2) sheet. The basis weight of paper can also be measured on the total area of a ream of paper, which is normally the case for the following types of printing and writing papers:

(1) *Bond paper* — 500 sheets, 17 in. × 22 in. (432 mm × 559 mm) = 1300 ft^2 (120.8 m^2) per ream
(2) *Book paper* — 500 sheets, 25 in. × 38 in. (635 mm × 965 mm) = 3300 ft^2 (306.6 m^2) per ream
(3) *Index paper* — 500 sheets, 25½ in. × 30½ in. (648 mm × 775 mm) = 2700 ft^2 (250.8 m^2) per ream
(4) *Bristol paper* — 500 sheets, 22½ in. × 35 in. (572 mm × 889 mm) = 2734 ft^2 (254 m^2) per ream
(5) *Tag paper* — 500 sheets, 24 in. × 36 in. (610 mm × 914 mm) = 3000 ft^2 (278.7 m^2) per ream

For the purposes of this standard, all basis weights are expressed in lb/1000 ft^2 (kg/92.9 m^2) of paper. To determine the basis weight per 1000 ft^2 (92.9 m^2) for papers measured on a sheet of different area, the following formula should be applied:

$$\frac{\text{Base weight}}{1000\ \text{ft}^2} = \text{basis weight} \times 1000\ \text{measured area}$$

Example: To determine the basis weight per 1000 ft^2 (92.9 m^2) of 16-lb (7.3-kg) bond paper:

$$\left(\frac{16\ \text{lb}}{1300\ \text{ft}^2}\right)1000 = \frac{12.3\ \text{lb}}{1000\ \text{ft}^2}$$

Table A.5.6.5 Paper Classification

Heavyweight	Mediumweight	Lightweight	Tissue
Linerboards	Bond and reproduction	Carbonizing tissue	Toilet tissue
Medium	Vellum	Cigarette	Towel tissue
Kraft roll wrappers	Offset	Fruit wrap	
Milk carton board	Tablet	Onion skin	
Folding carton board	Computer		
Bristol board	Envelope		
Tag	Book		
Vellum bristol board	Label		
Index	Magazine		
Cupstock	Butcher		
Pulp board	Bag		
	Newsprint (unwrapped)		

Large- and small-scale fire tests indicate that the burning rate of paper varies with the basis weight. Heavyweight paper burns more slowly than lightweight paper. Full-scale roll paper fire tests were conducted with the following types of paper:

(1) *Linerboard* — 42 lb/1000 ft^2 (19.1 kg/92.9 m^2) nominal basis weight
(2) *Newsprint* — 10 lb/1000 ft^2 (4.5 kg/92.9 m^2) nominal basis weight
(3) *Tissue* — 5 lb/1000 ft^2 (2.3 kg/92.9 m^2) nominal basis weight

The rate of firespread over the surface of the tissue rolls was extremely rapid in the full-scale fire tests. The rate of firespread over the surface of the linerboard rolls was slower. Based on the overall results of these full-scale tests, along with additional data from small-scale testing of various paper grades, the broad range of papers has been classified into three major categories as follows:

(1) *Heavyweight* — Basis weight of 20 lb/1000 ft^2 (9.1 kg/ 92.9 m^2) or greater
(2) *Mediumweight* — Basis weight of 10 lb to 20 lb/1000 ft^2 (4.5 kg to 9.1 kg/92.9 m^2)
(3) *Lightweight* — Basis weight of less than 10 lb/1000 ft^2 (4.5 kg/92.9 m^2) and tissues regardless of basis weight

The following SI units were used for conversion of English units:

1 lb = 0.454 kg
1 in. = 25.4 mm
1 ft = 0.3048 m
1 ft^2 = 0.0929 m^2

The various types of papers normally found in each of the four major categories are provided in Table A.5.6.5.

A.6.1.1 Included among items requiring listing are sprinklers, some pipe and some fittings, hangers, alarm devices, valves controlling flow of water to sprinklers, valve tamper switches, and gauges.

A.6.2.2 The four- to six-character sprinkler identification number, with no intervening spaces, is intended to identify the sprinkler operating characteristics in lieu of the traditional laboratory approval marking (e.g., SSU, SSP, EC, QR, etc.). The number, marked on the deflector of most sprinklers and elsewhere on decorative ceiling sprinklers, consists of one or two characters identifying the manufacturer, followed by three or four digits.

Sprinkler manufacturers have identified their manufacturer designations for the listing organizations. Each change in orifice size, response characteristics, or deflector (distribution) characteristics results in a new sprinkler identification number. The numbers do not identify specific characteristics of sprinklers but can be referenced in the database information compiled by the listing organizations. At the plan review stage, the sprinkler identification number should be checked against such a database or the manufacturer's literature to ensure that sprinklers are being used properly and within the limitations of their listings. Field inspections can include spot checks to ensure that the model numbers on the plans are those actually installed.

A.6.2.3.1 See Table A.6.2.3.1.

Table A.6.2.3.1 Nominal Sprinkler Orifice Sizes

Nominal K-factor	Nominal Orifice Size in.	Nominal Orifice Size mm
1.4	1/4	6.4
1.9	5/16	8.0
2.8	3/8	9.5
4.2	7/16	11.0
5.6	1/2	12.7
8.0	17/32	13.5
11.2	5/8	15.9
14.0	3/4	19.0
16.8	—	—
19.6	—	—
22.4	—	—
25.2	—	—
28.0	—	—

A.6.2.5 Information regarding the highest temperature that can be encountered in any location in a particular installation can be obtained by use of a thermometer that will register the highest temperature encountered; it should be hung for several days in the location in question, with the plant in operation.

A.6.2.6.1 Examples of such locations include the following:

(1) Paper mills
(2) Packing houses

(3) Tanneries
(4) Alkali plants
(5) Organic fertilizer plants
(6) Foundries
(7) Forge shops
(8) Fumigation, pickle, and vinegar works
(9) Stables
(10) Storage battery rooms
(11) Electroplating rooms
(12) Galvanizing rooms
(13) Steam rooms of all descriptions, including moist vapor dry kilns
(14) Salt storage rooms
(15) Locomotive sheds or houses
(16) Driveways
(17) Areas exposed to outside weather, such as piers and wharves exposed to salt air
(18) Areas under sidewalks
(19) Areas around bleaching equipment in flour mills
(20) All portions of cold storage buildings where a direct ammonia expansion system is used
(21) Portions of any plant where corrosive vapors prevail

A.6.2.6.1.2 Care should be taken in the handling and installation of wax-coated or similar sprinklers to avoid damaging the coating.

A.6.2.6.2 Painting of sprinklers can retard the thermal response of the heat-responsive element, can interfere with the free movement of parts, and can render the sprinkler inoperative. Moreover, painting can invite the application of subsequent coatings, thus increasing the possibility of a malfunction of the sprinkler.

A.6.2.7.2 The use of the wrong type of escutcheon with recessed or flush-type sprinklers can result in severe disruption of the spray pattern, which can destroy the effectiveness of the sprinkler.

A.6.2.8 Sprinklers under open gratings should be provided with shields. Shields over automatic sprinklers should not be less, in least dimension, than four times the distance between the shield and fusible element, except special sprinklers incorporating a built-in shield need not comply with this recommendation if listed for the particular application.

A.6.2.9.1 A minimum of two sprinklers of each type and temperature rating should be provided.

A.6.3.2 See Table A.6.3.2.

A.6.3.5 See Table A.6.3.5.

A.6.3.6 Other types of pipe and tube that have been investigated and listed for sprinkler applications include lightweight steel pipe and thermoplastic pipe and fittings. While these products can offer advantages, such as ease of handling and installation, cost-effectiveness, reduction of friction losses, and improved corrosion resistance, it is important to recognize that they also have limitations that are to be considered by those contemplating their use or acceptance.

Corrosion studies have shown that, in comparison to Schedule 40 pipe, the effective life of lightweight steel pipe can be reduced, the level of reduction being related to its wall thickness. Further information with respect to corrosion resistance is contained in the individual listings for such pipe.

With respect to thermoplastic pipe and fittings, exposure of such piping to elevated temperatures in excess of that for which it has been listed can result in distortion or failure. Accordingly, care must be exercised when locating such systems to ensure that the ambient temperature, including seasonal variations, does not exceed the rated value.

The upper service temperature limit of currently listed CPVC sprinkler pipe is 150°F (65.5°C) at 175 psi (12.1 bar). The upper service temperature limit of currently listed polybutylene sprinkler pipe is 120°F (49°C) at 175 psi (12.1 bar).

Not all pipe or tube made to ASTM F 442, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR),* and ASTM D 3309, *Standard Specification for Polybutylene (PB) Plastic Hot- and Cold-Water Distribution Systems,* as described in 6.3.6, is listed for fire sprinkler service. Listed pipe is identified by the logo of the listing agency.

Not all fittings made to ASTM F 437, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80;* ASTM F 438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40;* and ASTM F 439, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80,* as described in 6.4.3, are listed for fire sprinkler service. Listed fittings are identified by the logo of the listing agency.

Consideration must also be given to the possibility of exposure of the piping to elevated temperatures during a fire. The survival of thermoplastic piping under fire conditions is primarily due to the cooling effect of the discharge from the sprinklers it serves. As this discharge might not occur simultaneously with the rise in ambient temperature and, under some circumstances, can be delayed for periods beyond the tolerance of the piping, protection in the form of a fire-resistant membrane is generally required. (Some listings do provide for the use of exposed piping in conjunction with residential or quick-response sprinklers, but only under specific, limited installation criteria.)

Where protection is required, it is described in the listing information for each individual product, and the requirements given must be followed. It is equally important that such protection must be maintained. Removal of, for example, one or more panels in a lay-in ceiling can expose piping in the concealed space to the possibility of failure in the event of a fire. Similarly, the relocation of openings through protective ceilings that expose the pipe to heat, inconsistent with the listing, would place the system in jeopardy. The potential for loss of the protective membrane under earthquake conditions should also be considered.

While the listings of thermoplastic piping do not prohibit its installation in combustible concealed spaces where the provision of sprinkler protection is not required, and while the statistical record of fire originating in such spaces is low, it should be recognized that the occurrence of a fire in such a space could result in failure of the piping system.

The investigation of pipe and tube other than described in Table 6.3.1.1 should involve consideration of many factors, including the following:

(1) Pressure rating
(2) Beam strength (hangers)
(3) Unsupported vertical stability
(4) Movement during sprinkler operation (affecting water distribution)
(5) Corrosion (internal and external), chemical and electrolytic
(6) Resistance to failure when exposed to elevated temperatures
(7) Methods of joining (strength, permanence, fire hazard)
(8) Physical characteristics related to integrity during earthquakes

Table A.6.3.2 Steel Pipe Dimensions

Nominal Pipe Size (in.)	Outside Diameter		Schedule 5 Inside Diameter		Schedule 5 Wall Thickness		Schedule 10[a] Inside Diameter		Schedule 10[a] Wall Thickness		Schedule 30 Inside Diameter		Schedule 30 Wall Thickness		Schedule 40 Inside Diameter		Schedule 40 Wall Thickness	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
½[b]	0.840	21.3	—	—	—	—	0.674	17.0	0.083	2.1	—	—	—	—	0.622	15.8	0.109	2.8
¾[b]	1.050	26.7	—	—	—	—	0.884	22.4	0.083	2.1	—	—	—	—	0.824	21.0	0.113	2.9
1	1.315	33.4	1.185	30.1	0.065	1.7	1.097	27.9	0.109	2.8	—	—	—	—	1.049	26.6	0.133	3.4
1¼	1.660	42.2	1.530	38.9	0.065	1.7	1.442	36.6	0.109	2.8	—	—	—	—	1.380	35.1	0.140	3.6
1½	1.900	48.3	1.770	45.0	0.065	1.7	1.682	42.7	0.109	2.8	—	—	—	—	1.610	40.9	0.145	3.7
2	2.375	60.3	2.245	57.0	0.065	1.7	2.157	54.8	0.109	2.8	—	—	—	—	2.067	52.5	0.154	3.9
2½	2.875	73.0	2.709	68.8	0.083	2.1	2.635	66.9	0.120	3.0	—	—	—	—	2.469	62.7	0.203	5.2
3	3.500	88.9	3.334	84.7	0.083	2.1	3.260	82.8	0.120	3.0	—	—	—	—	3.068	77.9	0.216	5.5
3½	4.000	101.6	3.834	97.4	0.083	2.1	3.760	95.5	0.120	3.0	—	—	—	—	3.548	90.1	0.226	5.7
4	4.500	114.3	4.334	110.1	0.083	2.1	4.260	108.2	0.120	3.0	—	—	—	—	4.026	102.3	0.237	6.0
5	5.563	141.3	—	—	—	—	5.295	134.5	0.134	3.4	—	—	—	—	5.047	128.2	0.258	6.6
6	6.625	168.3	6.407	162.7	0.109	2.8	6.357	161.5	0.134[c]	3.4	—	—	—	—	6.065	154.1	0.280	7.1
8	8.625	219.1	—	—	—	—	8.249	209.5	0.188[c]	4.8	8.071	205.0	0.277	7.0	7.981	—	0.322	—
10	10.750	273.1	—	—	—	—	10.370	263.4	0.188[c]	4.8	10.140	257.6	0.307	7.8	10.020	—	0.365	—
12	12.750	—	—	—	—	—	12.090	—	0.330	—	—	—	—	—	11.938	—	0.406	—

[a] Schedule 10 defined to 5-in. (127-mm) nominal pipe size by ASTM A 135, *Standard Specification for Electric-Resistance-Welded Steel Pipe.*
[b] These values applicable when used in conjunction with 8.14.19.3 and 8.14.19.4.
[c] Wall thickness specified in 6.3.2 and 6.3.3.

Table A.6.3.5 Copper Tube Dimensions

Nominal Tube Size (in.)	Outside Diameter		Type K Inside Diameter		Type K Wall Thickness		Type L Inside Diameter		Type L Wall Thickness		Type M Inside Diameter		Type M Wall Thickness	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
¾	0.875	22.2	0.745	18.9	0.065	1.7	0.785	19.9	0.045	1.1	0.811	20.6	0.032	0.8
1	1.125	28.6	0.995	25.3	0.065	1.7	1.025	26.0	0.050	1.3	1.055	26.8	0.035	0.9
1¼	1.375	34.9	1.245	31.6	0.065	1.7	1.265	32.1	0.055	1.4	1.291	32.8	0.042	1.1
1½	1.625	41.3	1.481	37.6	0.072	1.8	1.505	38.2	0.060	1.5	1.527	38.8	0.049	1.2
2	2.125	54.0	1.959	49.8	0.083	2.1	1.985	50.4	0.070	1.8	2.009	51.0	0.058	1.5
2½	2.625	66.7	2.435	61.8	0.095	2.4	2.465	62.6	0.080	2.0	2.495	63.4	0.065	1.7
3	3.125	79.4	2.907	73.8	0.109	2.8	2.945	74.8	0.090	2.3	2.981	75.7	0.072	1.8
3½	3.625	92.1	3.385	86.0	0.120	3.0	3.425	87.0	0.100	2.5	3.459	87.9	0.083	2.1
4	4.125	104.8	3.857	98.0	0.134	3.4	3.905	99.2	0.110	2.8	3.935	99.9	0.095	2.4
5	5.125	130.2	4.805	122.0	0.160	4.1	4.875	123.8	0.125	3.2	4.907	124.6	0.109	2.8
6	6.125	155.6	5.741	145.8	0.192	4.9	5.845	148.5	0.140	3.6	5.881	149.4	0.122	3.1
8	8.125	206.4	7.583	192.6	0.271	6.9	7.725	196.2	0.200	5.1	7.785	197.7	0.170	4.3
10	10.130	257.3	9.449	240.0	0.338	8.6	9.625	244.5	0.250	6.4	9.701	246.4	0.212	5.4

A.6.4.3 Rubber-gasketed pipe fittings and couplings should not be installed where ambient temperatures can be expected to exceed 150°F (66°C) unless listed for this service. If the manufacturer further limits a given gasket compound, those recommendations should be followed.

A.6.4.4 The rupture strength of cast-iron fittings 2 in. (50.8 mm) in size and smaller and malleable iron fittings 6 in. (152.4 mm) in size and smaller is sufficient to provide an adequate factor of safety.

A.6.4.5 Listed flexible connections are permissible and encouraged for sprinkler installations in racks to reduce the possibility of physical damage. Where flexible tubing is used, it should be located so that it will be protected against mechanical injury.

A.6.5.1.2 Some steel piping material having lesser wall thickness than specified in 6.5.1.2 has been listed for use in sprinkler systems where joined with threaded connections. The service life of such products can be significantly less than that of Schedule 40 steel pipe, and it should be determined if this service life will be sufficient for the application intended.

All such threads should be checked by the installer using working ring gauges conforming to the "Basic Dimensions of Ring Gauges for USA (American) Standard Taper Pipe Threads, NPT," as per Table 8 of ASME B1.20.1, *Pipe Threads, General Purpose, (Inch).*

A.6.5.2 See Figure A.6.5.2(a) and Figure A.6.5.2(b).

A.6.5.2.2 Cutting and welding operations account for 4 percent of fires each year in nonresidential properties and 8 percent in industrial and manufacturing properties. In-place welding of sprinkler piping introduces a significant hazard that can normally be avoided by shop-welding the piping and installing the welded sections with mechanical fittings. As a

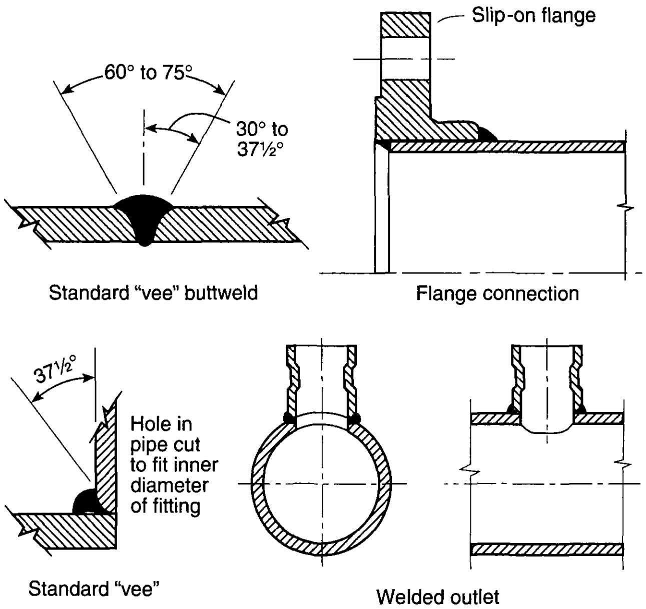


FIGURE A.6.5.2(a) Acceptable Weld Joints.

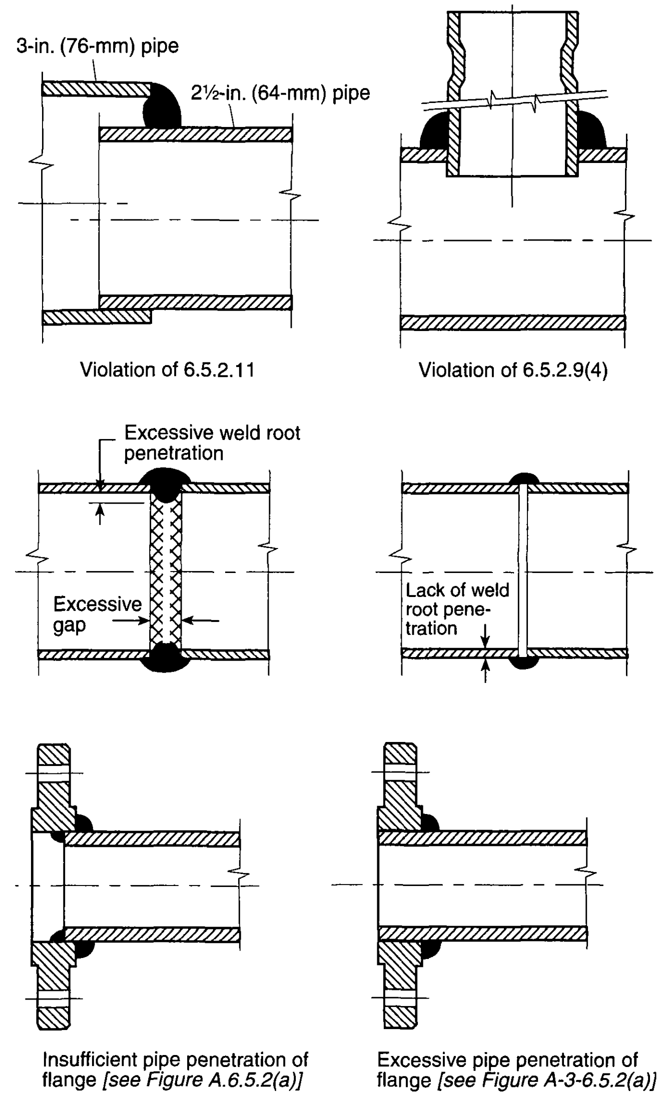


FIGURE A.6.5.2(b) Unacceptable Weld Joints.

result, the standard requires that all piping be shop-welded. When such situations cannot be avoided, the exceptions outline procedures and practices that minimize the increase in hazard.

A.6.5.2.9(1) Listed, shaped, contoured nipples meet the definition of fabricated fittings.

A.6.5.4 The fire hazard of the brazing and soldering processes should be suitably safeguarded.

A.6.5.4.5 Soldering fluxes manufactured to the specifications required by Table 6.3.1.1 are unlikely to cause damage to the seats of sprinklers. When brazing flux is used, it must be of a type not likely to damage the seats of sprinklers.

A.6.6 See Section 9.1 for information pertaining to the type of hangers and hanger components acceptable for use on a sprinkler system.

A.6.7.4 The intent of 6.7.4 is to provide assistance in determining the area of a building served by a particular control valve.

A.6.9.2.4 The surge of water that occurs when the valve trips can seriously damage the device.

A.6.9.3.1 Audible alarms are normally located on the outside of the building. Listed electric gongs, bells, horns, or sirens inside the building, or a combination of such used inside and outside, are sometimes advisable.

Outside alarms can be omitted where the sprinkler system is used as part of a central station, auxiliary, remote station, or proprietary signaling fire alarm system utilizing listed audible inside alarm devices.

A.6.9.3.2 All alarm apparatus should be so located and installed that all parts are accessible for inspection, removal, and repair, and such apparatus should be substantially supported.

The water motor gong bell mechanism should be protected from weather-related elements such as rain, snow, or ice. To the extent practicable, it should also be protected from other influencing factors such as birds or other small animals that might attempt to nest in such a device.

A.6.9.4 Switches that will silence electric alarm-sounding devices by interruption of electric current are not desirable; however, if such means are provided, then the electric alarm-sounding device circuit should be arranged so that, when the sounding device is electrically silenced, that fact should be indicated by means of a conspicuous light located in the vicinity of the riser or alarm control panel. This light should remain in operation during the entire period of the electric circuit interruption.

A.7.2 A dry pipe system should be installed only where heat is not adequate to prevent freezing of water in all parts of, or in sections of, the system. Dry pipe systems should be converted to wet pipe systems when they become unnecessary because adequate heat is provided. Sprinklers should not be shut off in cold weather.

Where two or more dry pipe valves are used, systems preferably should be divided horizontally to prevent simultaneous operation of more than one system and the resultant in-

creased time delay in filling systems and discharging water and to prevent receipt of more than one waterflow alarm signal.

Where adequate heat is present in sections of the dry pipe system, consideration should be given to dividing the system into a separate wet pipe system and dry pipe system. Minimized use of dry pipe systems is desirable where speed of operation is of particular concern.

A.7.2.2(2) Installation limitations of listed dry pendent sprinklers can vary with different products. Limitations should be included in product installation instructions to warn the user of the potential accumulation of water, scale, and sediment from collecting at the sprinkler.

A.7.2.3 The capacities of the various sizes of pipe given in Table A.7.2.3 are for convenience in calculating the capacity of a system.

A.7.2.3.1 The 60-second limit does not apply to dry systems with capacities of 500 gal (1893 L) or less, nor to dry systems with capacities of 750 gal (2839 L) or less if equipped with a quick-opening device.

A.7.2.5 The dry pipe valve should be located in an accessible place near the sprinkler system it controls. Where exposed to cold, the dry pipe valve should be located in a valve room or enclosure of adequate size to properly service equipment.

A.7.2.5.1 The dry pipe valve and supply piping should be in an area maintained at or above 40°F (4°C). It is the intent of the committee to protect the valves from freezing. The occasional exposure of valves to short exposures of air temperatures below 40°F (4°C) that would not cause the valves to freeze does not justify the construction of a valve room.

A.7.2.6.2 The compressor should draw its air supply from within the operating criteria allowed by the manufacturer of the compressor. Air piping should not be attached to the intake of the compressor unless acceptable to the compressor manufacturer and installed in accordance with 7.8.2.7. Damage, air reduction, or reduced life expectancy can result if guidelines are not followed.

A.7.3.1 Conditions of occupancy or special hazards might require quick application of large quantities of water, and, in such cases, deluge systems might be needed.

Fire detection devices should be selected to assure operation yet guard against premature operation of sprinklers based on normal room temperatures and draft conditions.

In locations where ambient temperature at the ceiling is high from heat sources other than fire conditions, heat-responsive devices that operate at higher than ordinary temperature and that are capable of withstanding the normal high temperature for long periods of time should be selected.

Where corrosive conditions exist, materials or protective coatings that resist corrosion should be used.

To help avoid ice formation in piping due to accidental tripping of dry pipe valves in cold storage rooms, a deluge automatic water control valve can be used on the supply side of the dry pipe valve. Where this method is employed, the following also apply:

(1) Dry systems can be manifolded to a deluge valve, with the protected area not exceeding 40,000 ft^2 (3716 m^2).
(2) Where a dry system is manifolded to a deluge valve, the distance between valves should be as short as possible to minimize water hammer.
(3) The dry pipe valves should be pressurized to 50 psi (3.4 bar) to reduce the possibility of dry pipe valve operation from water hammer.

A.7.3.2.3 Supervision, either electrical or mechanical, as used in 7.3.2.3 refers to constant monitoring of piping and detection equipment to ensure the integrity of the system. Detection devices of listed flow cycling assemblies that cause an alarm during a single open or a single ground fault condition should be considered to satisfy the supervision requirement.

A.7.3.2.4(2) See A.7.2.2(2).

A.7.3.3 Where 8-in. (203-mm) piping is employed to reduce friction losses in a system operated by fire detection devices, a 6-in. (152-mm) preaction or deluge valve and a 6-in. (152-mm) gate valve between tapered reducers should be permitted.

A.7.4.1 Systems described by Section 7.4 are special types of noninterlocking preaction systems intended for use in, but not limited to, structures where a number of dry pipe valves would be required if a dry pipe system were installed. These systems are primarily used in piers and wharves.

A.7.4.1.1 See Figure A.7.4.1.1.

A.7.4.1.4(2) See A.7.2.2(2).

A.7.4.3 See Figure A.7.4.3.

Table A.7.2.3 Capacity of 1 ft of Pipe (Based on Actual Internal Pipe Diameter)

Nominal Pipe Diameter (in.)	Pipe		Nominal Pipe Diameter (in.)	Pipe	
	Schedule 40 (gal)	Schedule 10 (gal)		Schedule 40 (gal)	Schedule 10 (gal)
¾	0.028		3	0.383	0.433
1	0.045	0.049	3½	0.513	0.576
1¼	0.078	0.085	4	0.660	0.740
1½	0.106	0.115	5	1.040	1.144
2	0.174	0.190	6	1.501	1.649[b]
2½	0.248	0.283	8	2.66[a]	2.776[c]

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m; 1 gal = 3.785 L.
[a] Schedule 30.
[b] 0.134 wall pipe.
[c] 0.188 wall pipe.

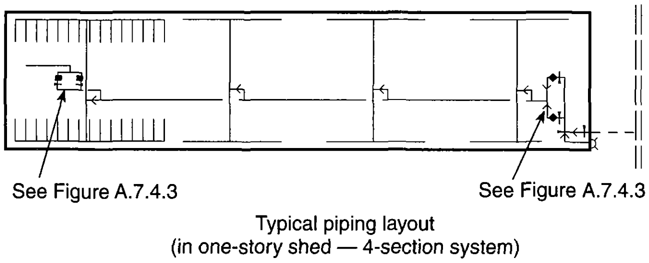


FIGURE A.7.4.1.1 Typical Piping Layout for Combined Dry Pipe and Preaction Sprinkler System.

A.7.5.2 Listed CPVC sprinkler pipe and fittings should be protected from freezing with glycerine only. The use of diethylene, ethylene, or propylene glycols are specifically prohibited. Laboratory testing shows that glycol-based antifreeze solutions present a chemical environment detrimental to CPVC.

A.7.5.2.4 Beyond certain limits, an increased proportion of antifreeze does not lower the freezing point of solution *(see Figure A.7.5.2.4).*

Glycerine, diethylene glycol, ethylene glycol, and propylene glycol should never be used without mixing with water in proper proportions, because these materials tend to thicken near 32°F (0°C).

A.7.5.3.1 All permitted antifreeze solutions are heavier than water. At the point of contact (interface), the heavier liquid will be below the lighter liquid, preventing diffusion of water into the unheated areas.

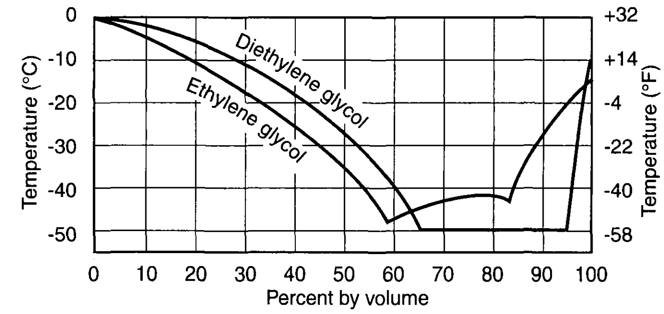


FIGURE A.7.5.2.4 Freezing Points of Water Solutions of Ethylene Glycol and Diethylene Glycol.

A.7.5.3.2 One formula for sizing the chamber is as follows. Other methods also exist.

$$\Delta L = S_V\left(\frac{D_L}{D_H} - 1\right)$$

where:

ΔL = change in antifreeze solution volume (gal) due to thermal expansion

S_V = volume (gal) of antifreeze system, not including the expansion chamber

D_L = density (gm/ml) of antifreeze solution at lowest expected temperature

D_H = density (gm/ml) of antifreeze solution at highest expected temperature

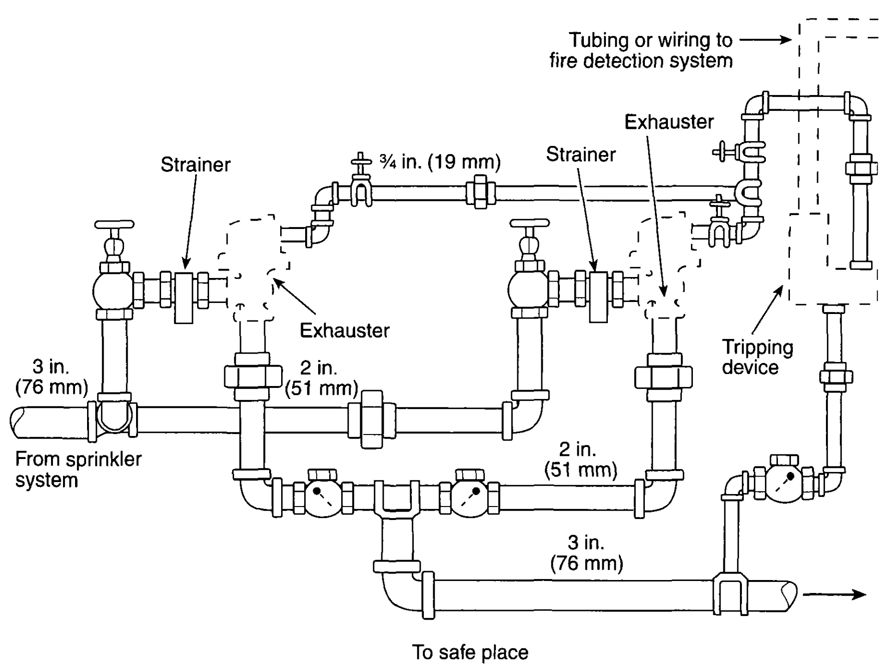


FIGURE A.7.4.3 Arrangement of Air Exhaust Valves for Combined Dry Pipe and Preaction Sprinkler System.

This method is based on the following information:

$$\frac{P_0 \cdot V_0}{T_0} = \frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$

where:

V_{EC} = minimum required volume (gal) of expansion chamber
V_0 = air volume (gal) in expansion chamber at precharge (before installation)
V_1 = air volume (gal) in expansion chamber at normal static pressure
V_2 = air volume (gal) in expansion chamber at post-expansion pressure (antifreeze at high temperature)
P_0 = absolute precharge pressure (psia) on expansion chamber before installation
P_1 = absolute static pressure (psi) on water (supply) side of backflow preventer
P_2 = absolute maximum allowable working pressure (psi) for antifreeze system
T_0 = temperature (°R) of air in expansion chamber at precharge
T_1 = temperature (°R) of air in expansion chamber when antifreeze system piping is at lowest expected temperature
T_2 = temperature (°R) of air in expansion chamber when antifreeze system piping is at highest expected temperature

This equation is one formulation of the ideal gas law from basic chemistry. The amount of air in the expansion chamber will not change over time. The pressure, temperature, and volume of the air at different times will be related in accordance with this formula.

$$V_2 = V_1 - \Delta L$$

The antifreeze in the system is essentially incompressible, so the air volume in the expansion chamber will decrease by an amount equal to the expansion of the antifreeze.

It is assumed that there is no trapped air in the system piping, so the only air in the system is in the expansion chamber. This is a conservative assumption, since more air is better. In reality, there will be at least some trapped air. However, only the air in the expansion chamber can be relied upon to be available when needed.

$$V_{EC} = V_0$$

At precharge, the chamber will be completely full of air.

$$V_{EC} = \frac{P_1 \cdot T_0 \cdot P_2 \cdot \Delta L \cdot T_1}{P_0 \cdot T_1 \left(P_2 \cdot T_1 - P_1 \cdot T_2\right)}$$

In cases where the normal static pressure on the sprinkler system is close to the maximum working pressure, antifreeze systems are not advisable if the connection to the wet pipe system will incorporate a backflow device. In these cases, expansion of the antifreeze solution during warm weather will cause the antifreeze system to exceed the maximum working pressure, regardless of the size of the expansion chamber. The normal static pressure is too close to the maximum working pressure if the formula for V_{EC} above yields a negative result. If this occurs, use a dry pipe system instead or install a pressure reducing valve before the backflow preventer.

A.7.6.1.2 Outlets should be provided at critical points on sprinkler system piping to accommodate attachment of pressure gauges for test purposes.

A.7.7.2.1 The water supply should be capable of furnishing the total demand for all exposure sprinklers operating simultaneously for protection against the exposure fire under consideration for a duration of not less than 60 minutes.

A.7.8 Careful installation and maintenance, and some special arrangements of piping and devices as outlined in this section, are needed to avoid the formation of ice and frost inside piping in cold storage rooms that will be maintained at or below 32°F (0°C). Conditions are particularly favorable to condensation where pipes enter cold rooms from rooms having temperatures above freezing.

Whenever the opportunity offers, fittings such as those specified in 7.8.2.1, as well as flushing connections, should be provided in existing systems.

Where possible, risers should be located in stair towers or other locations outside of refrigerated areas, which would reduce the probabilities of ice or frost formation within the riser (supply) pipe.

Cross mains should be connected to risers or feed mains with flanges. In general, flanged fittings should be installed at points that would allow easy dismantling of the system. Split ring or other easily removable types of hangers will facilitate the dismantling.

Because it is not practical to allow water to flow into sprinkler piping in spaces that might be constantly subject to freezing, or where temperatures must be maintained at or below 40°F (4.4°C), it is important that means be provided at the time of system installation to conduct trip tests on dry pipe valves that service such systems. NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* contains requirements in this matter.

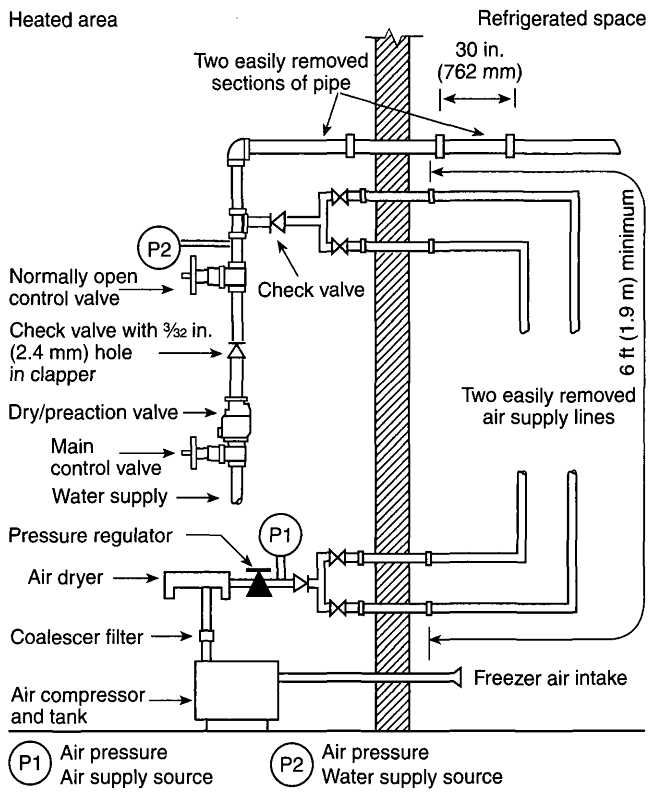
A.7.8.2 The requirements in 7.8.2 are intended to minimize the chances of ice plug formation inside sprinkler system piping protecting freezers.

A.7.8.2.4 A higher degree of preventing the formation of ice blocks can be achieved by lowering the moisture of the air supply entering the refrigerated space to a pressure dew point no greater than 20°F (−6.6°C) below the lowest nominal temperature of the refrigerated space. The pressure dew point of the air supply can cause moisture to condense and freeze in sprinkler pipe even when the air supply is from the freezer. One method of reducing the moisture content of the air by use of air drying systems is illustrated in Figure A.7.8.2.4.

When compressors and dryers are used for an air supply, consideration should be given to pressure requirements of the regenerative dryers, compressor size, air pressure regulator capacity, and air fill rate. Application of these factors could necessitate the use of increased air pressures and a larger air compressor.

The compressed air supply should be properly prepared prior to entering a regenerative-type air dryer, such as minimum air pressure, maximum inlet air temperature, and proper filtration of compressed air.

A.7.8.2.5 A major factor contributing to the introduction of moisture into the system piping is excessive air compressor operation caused by system leakage. Where excessive compressor operation is noted or ice accumulates in the air supply piping, the system should be checked for leakage and appropriate corrective action should be taken.



Notes:

1. If pressure gauge P1 and P2 do not indicate equal pressures, it could mean the air line is blocked or the air supply is malfunctioning.
2. Air dryer and coalescer filter not required when system piping capacity is less than 250 gal (946 L).

FIGURE A.7.8.2.4 Refrigerator Area Sprinkler Systems Used to Minimize the Chances of Developing Ice Plugs.

A.7.8.2.6 The purpose of the check valve is to prevent evaporation of prime water into the system piping.

A.7.8.2.7 The dual lines feeding the system air entering the cold area are intended to facilitate continued service of the system when one line is removed for inspection. It should be noted that, when using a system as described in Figure A.7.8.2.4, differences in the pressures at gauge P1 and gauge P2 indicate blockage in the air supply line or other malfunctions.

A.7.9.2 See Figure A.7.9.2.

A.8.1 The installation requirements are specific for the normal arrangement of structural members. There will be arrangements of structural members not specifically detailed by the requirements. By applying the basic principles, layouts for such construction can vary from specific illustrations, provided the maximums specified for the spacing and location of sprinklers (Section 8.4) are not exceeded.

Where buildings or portions of buildings are of combustible construction or contain combustible material, standard fire barriers should be provided to separate the areas that are sprinkler protected from adjoining unsprinklered areas. All openings should be protected in accordance with applicable standards, and no sprinkler piping should be placed in an unsprinklered area unless the area is permitted to be unsprinklered by this standard.

Water supplies for partial systems should be designed with consideration to the fact that in a partial system more sprinklers might be opened in a fire that originates in an unprotected area and spreads to the sprinklered area than would be the case in a completely protected building. Fire originating in a nonsprinklered area might overpower the partial sprinkler system.

Where sprinklers are installed in corridors only, sprinklers should be spaced up to the maximum of 15 ft (4.5 m) along the corridor, with one sprinkler opposite the center of any door or pair of adjacent doors opening onto the corridor, and with an additional sprinkler installed inside each adjacent room above the door opening. Where the sprinkler in the adjacent room provides full protection for that space, an additional sprinkler is not required in the corridor adjacent to the door.

A.8.1.1 This standard contemplates full sprinkler protection for all areas including walk-in coolers, freezers, bank vaults, and similar areas. Other NFPA standards that mandate sprinkler installation might not require sprinklers in certain areas. The requirements of this standard should be used insofar as they are applicable. The authority having jurisdiction should be consulted in each case. A building is considered sprinklered throughout when protected in accordance with the requirements of this standard.

A.8.1.2 The components need not be open or exposed. Doors, removable panels, or valve pits can satisfy this need. Such equipment should not be obstructed by such permanent features as walls, ducts, columns, or direct burial.

A.8.3.1.1 The evaluation for usage should be based upon a review of available technical data.

A.8.3.1.3 The purpose of this requirement is to minimize the obstruction of the discharge pattern.

A.8.3.2.1 For protection of baled cotton, limited tests and actual fire experience indicate an initial low heat release; thus, sprinklers in the ordinary temperature range should offer some advantage by opening faster than those of intermediate- or high-temperature classifications under similar conditions.

A.8.3.2.7 Where high temperature–rated sprinklers are installed at the ceiling, high temperature–rated sprinklers also should extend beyond storage in accordance with Table A.8.3.2.7.

A.8.3.3.1 When renovations occur in an existing building and no changes are made in the existing sprinkler system, this section is not intended to require the replacement of existing standard sprinklers with quick-response sprinklers.

A.8.4 The selection of a sprinkler type will vary by occupancy. Where more than one type of sprinkler is used within a compartment, sprinklers with similar response characteristics should be used (i.e., standard or quick response). However, some hazards might benefit from designs that include the use of both standard and quick-response sprinklers. Examples include rack storage protected by standard-response ceiling sprinklers and quick-response in-rack sprinklers. Another case might include opening protection using closely spaced quick-response sprinklers with standard-response sprinklers in the adjoining areas. Other designs can be compromised when sprinklers of differing sensitivity are mixed. An example is a system utilizing ESFR sprinklers adjacent to a system using high-temperature standard-response sprinklers as might be found in a warehouse. In this case, a fire occurring near the boundary might open ESFR sprinklers, which would not be contemplated in the standard-response system design.

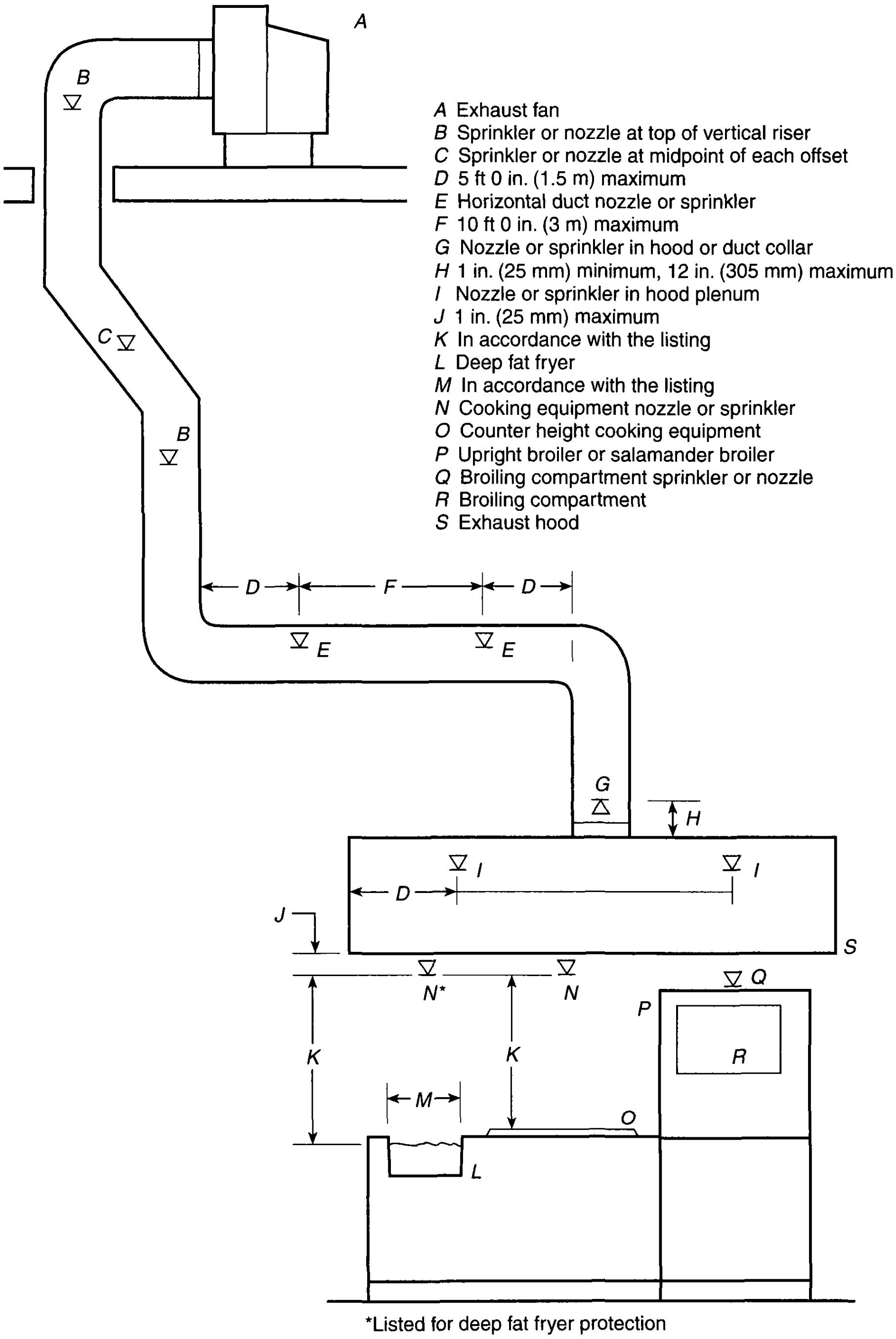


FIGURE A.7.9.2 Typical Installation Showing Automatic Sprinklers or Automatic Nozzles Being Used for the Protection of Commercial Cooking Equipment and Ventilation Systems.

Table A.8.3.2.7 Distance Beyond Perimeter of Storage for High-Hazard Occupancies Protected with High Temperature–Rated Sprinklers

Design Area		Distance	
ft²	m²	ft	m
2000	186.0	30	9.1
3000	278.7	40	12.0
4000	371.6	45	13.7
5000	464.5	50	15.2
6000	557.4	55	16.7

A.8.4.5.1 The response and water distribution pattern of listed residential sprinklers have been shown by extensive fire testing to provide better control than spray sprinklers in residential occupancies. These sprinklers are intended to prevent flashover in the room of fire origin, thus improving the chance for occupants to escape or be evacuated.

The protection area for residential sprinklers is defined in the listing of the sprinkler as a maximum square or rectangular area. Listing information is presented in even 2-ft (0.65-m) increments from 12 ft to 20 ft (3.9 m to 6.5 m). When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 13 ft 6 in. (4.4 m) wide and 17 ft 6 in. (5.6 m) long, a sprinkler that is listed to protect a rectangular area of 14 ft × 18 ft (4.5 m × 5.8 m) or a square area of 18 ft × 18 ft (5.8 m × 5.8 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

A.8.4.6.3 Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Table 8.12.2.2.1 is satisfied for each storage area.

A.8.4.7.2 The purpose of this requirement is to avoid scale accumulation.

A.8.4.9.1 Tests of standard sprinklers by approved laboratories have traditionally encompassed a fire test using a 350-lb (160-kg) wood crib and water distribution tests in which water is collected in pans from several arrangements of sprinklers to evaluate distribution under non-fire conditions.

Tests of special sprinklers are customized to evaluation responsiveness, distribution, and other unique characteristics of the sprinkler to control or suppress a fire. Depending on the intended use, these tests may include variables such as the following:

(1) The location of the fire relative to the sprinklers (i.e., below one sprinkler, between two or between four sprinklers)
(2) Fire conditions that encompass a variety of fire growth rates representative of anticipated conditions of use
(3) Tests where multiple sprinklers are expected to operate
(4) Adverse conditions of use (i.e., pipe shadows or other obstructions to discharge)
(5) Effect of a fire plume on water sprinkler discharge

The listing of new sprinkler technology for storage protection should include large scale fire testing using a commodity or commodities representative of those intended to be protected and should consider at least the following variables:

(1) Ignition under one, between two, and between four sprinklers
(2) Range of clearances between the sprinkler and the commodity
(3) Test(s) at or near the minimum pressures specified for the sprinkler

A.8.5.4.1 Batt insulation creates an effective thermal barrier and can be considered the ceiling/roof deck when determining distances between deflector and ceiling. The insulation needs to be installed in each pocket (not just above the sprinkler) and attached to the ceiling/roof in such a manner that it will not fall out during a fire prior to sprinkler activation.

A.8.5.5.1 See Figure A.8.5.5.1.

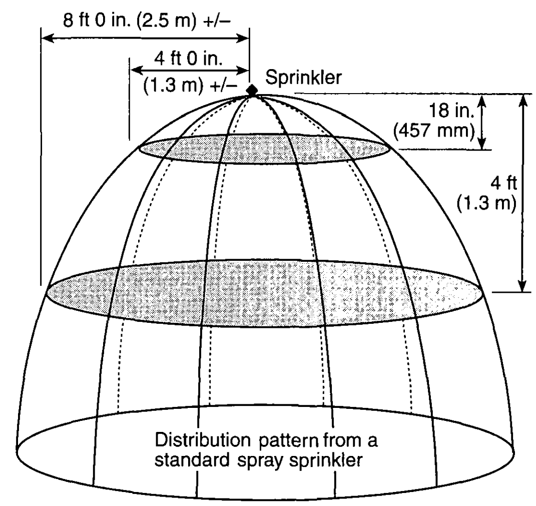


FIGURE A.8.5.5.1 Obstructions to Sprinkler Discharge Pattern Development for Standard Upright or Pendent Spray Sprinklers.

A.8.5.5.2 Where of a depth that will obstruct the spray discharge pattern, girders, beams, or trusses forming narrow pockets of combustible construction along walls can require additional sprinklers.

A.8.5.5.3 Frequently, additional sprinkler equipment can be avoided by reducing the width of decks or galleries and providing proper clearances. Slatting of decks or walkways or the use of open grating as a substitute for automatic sprinklers thereunder is not acceptable. The use of cloth or paper dust tops for rooms forms obstruction to water distribution. If dust tops are used, the area below should be sprinklered.

A.8.5.6 The fire protection system design should consider the maximum storage height. For new sprinkler installations, maximum storage height is the usable height at which commodities can be stored above the floor while the minimum required unobstructed space below sprinklers is maintained. Where evaluating existing situations, maximum storage height is the maximum existing storage height if space between the sprinklers and storage is equal to or greater than that required.

Building heights where baled cotton is stored should allow for proper clearance between the pile height and sprinkler deflectors. Fire tests of high-piled storage have shown that sprinklers are generally more effective if located 1½ ft to 4½ ft (0.45 m to 1.4 m) above the storage height.

A.8.6.2.2.1 When the spacing between sprinklers perpendicular to the slope exceeds 8 ft, it is necessary to increase the minimum density or sprinkler operating pressure as noted in Table 8.6.2.2.1(a) and in 8.6.4.1.4. Time to sprinkler activation and water distribution can be affected within combustible concealed spaces with sloped roofs or ceilings in these combustible concealed spaces especially where wood joist rafters or wood truss construction is used. To reduce the probability of fires in these combustible concealed spaces involving the combustible roof or ceiling construction above standard spray sprinklers, more stringent spacing and installation guidelines apply.

A.8.6.3.2.3 See Figure A.8.6.3.2.3.

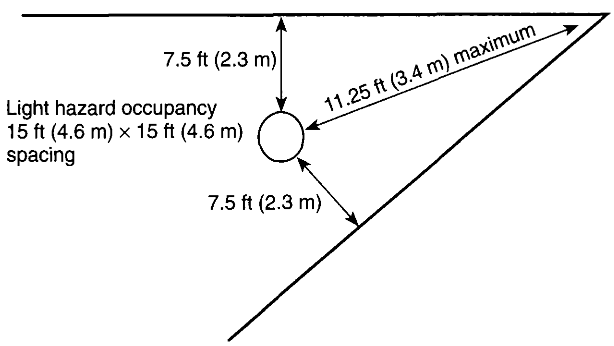


FIGURE A.8.6.3.2.3 Maximum Distance from Walls.

A.8.6.3.2.4 An example of sprinklers in small rooms for hydraulically designed and pipe schedule systems is shown in Figure A.8.6.3.2.4(a), and examples for hydraulically designed systems only are shown in Figure A.8.6.3.2.4(b), Figure A.8.6.3.2.4(c), and Figure A.8.6.3.2.4(d).

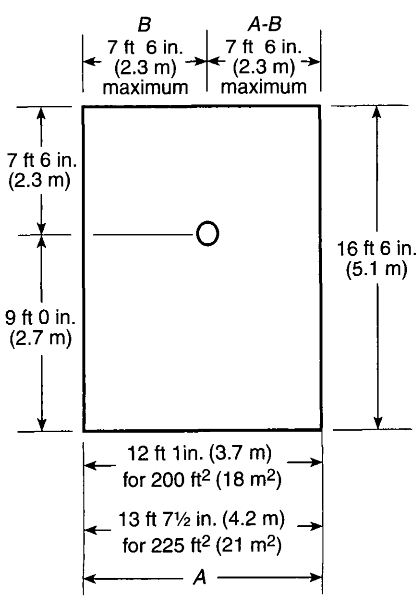


FIGURE A.8.6.3.2.4(a) Small Room Provision — One Sprinkler.

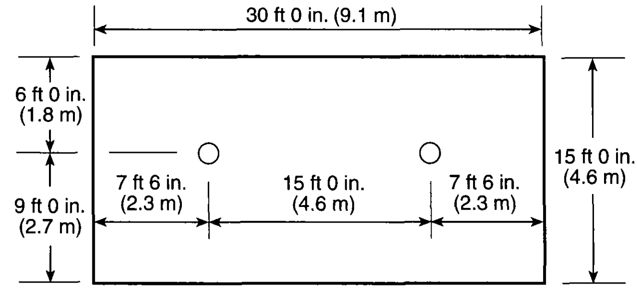


FIGURE A.8.6.3.2.4(b) Small Room Provision — Two Sprinklers Centered Between Sidewalls.

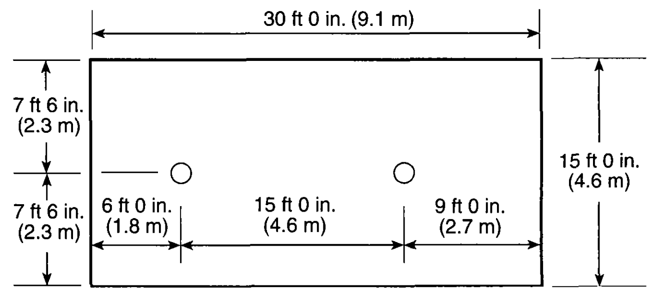


FIGURE A.8.6.3.2.4(c) Small Room Provision — Two Sprinklers Centered Between Top and Bottom Walls.

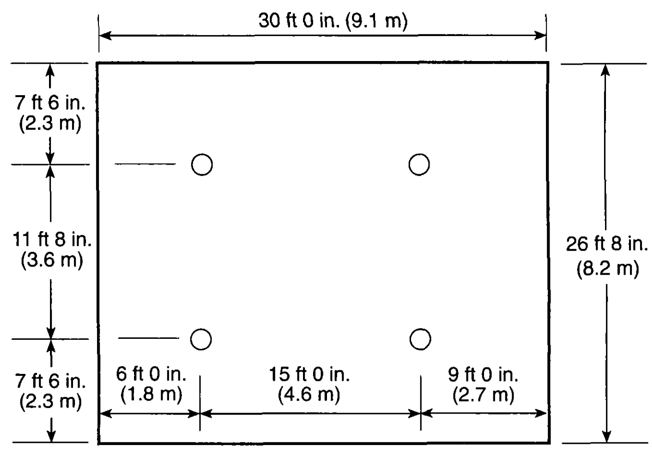


FIGURE A.8.6.3.2.4(d) Small Room Provision — Four Sprinklers.

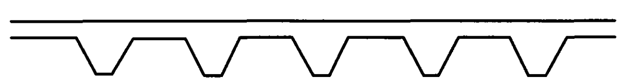


FIGURE A.8.6.4.1.2(5) Typical Concrete Joist Construction.

A.8.6.4.1.2(5) For concrete joists spaced less than 3 ft (0.91 m) on center, the rules for obstructed construction shown in 8.6.4.1.2 apply. *[See Figure A.8.6.4.1.2(5).]*

A.8.6.4.1.3.2 Saw-toothed roofs have regularly spaced monitors of saw tooth shape, with the nearly vertical side glazed and usually arranged for venting. Sprinkler placement is limited to a maximum of 3 ft (0.91 m) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

A.8.6.4.2 On sprinkler lines larger than 2 in. (51 mm), consideration should be given to the distribution interference caused by the pipe, which can be minimized by installing sprinklers on riser nipples or installing sprinklers in the pendent position.

A.8.6.5.2.1.3 The rules of 8.6.5.2.1.3 (known as the "Three Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.6.5.1.2 is necessary.

A.8.6.5.2.1.4 It is the intent of this section to exempt nonstructural elements in light and ordinary hazard occupancies from the obstruction criteria commonly called the "Three Times Rule." However, the other obstruction rules including the "Beam Rule" (8.6.5.1.2) and the "Wide Obstruction Rule" (8.6.5.3.3) still apply. If an obstruction is so close to a sprinkler that water cannot spray on both sides, it is effectively a continuous obstruction as far as the sprinkler is concerned and the Beam Rule should be applied.

It is not the intent of this section to permit the use of fixtures and architectural features or treatments to conceal, obscure, or otherwise obstruct sprinkler discharge. The exception should be applied in accordance with the performance objectives in 8.6.5.1.

A.8.6.5.2.2 The use of mesh can affect the discharge pattern of the sprinkler. Top mesh can be used when it has a minimum vertical distance of 18 in. below the sprinkler deflector with mesh openings having a minimum percent opening of 70 percent or larger.

A.8.6.5.3 See A.8.5.5.3.

A.8.6.6 The 18-in. (457-mm) dimension is not intended to limit the height of shelving on a wall or shelving against a wall in accordance with 8.6.6. Where shelving is installed on a wall and is not directly below sprinklers, the shelves, including storage thereon, can extend above the level of a plane located 18 in. (457 mm) below ceiling sprinkler deflectors. Shelving, and any storage thereon, directly below the sprinklers cannot extend above a plane located 18 in. (457 mm) below the ceiling sprinkler deflectors.

A.8.7.5.2.1.3 The rules of 8.7.5.2.1.3 (known as the "Three Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.7.5.1.2 is necessary.

A.8.7.5.3 See A.8.5.5.3.

A.8.8.2.1 The protection area for extended coverage upright and pendent sprinklers is defined in the listing of the sprinkler as a maximum square area. Listing information is presented in even 2-ft (0.6-m) increments up to 20 ft (6.1 m). When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 13½ ft (4.1 m) wide and 17½ ft (5.3 m) long as indicated in Figure A.8.8.2.1, a sprinkler that is listed to protect an area of 18 ft × 18 ft (5.5 m × 5.5 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

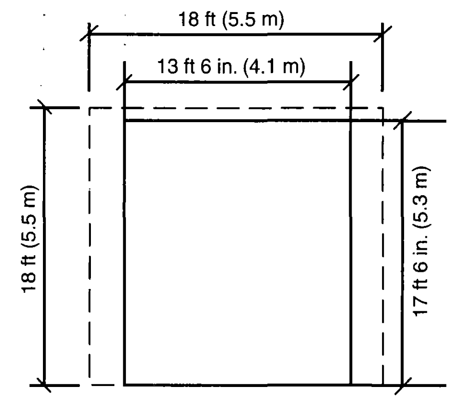


FIGURE A.8.8.2.1 Determination of Protection Area of Coverage for Extended Coverage Upright and Pendent Sprinklers.

A.8.8.4.1.3 Saw-toothed roofs have regularly spaced monitors of saw tooth shape, with the nearly vertical side glazed and usually arranged for venting. Sprinkler placement is limited to a maximum of 3 ft (0.91 m) down the slope from the peak because of the effect of venting on sprinkler sensitivity.

A.8.8.5.2.1.3 The rules of 8.8.5.2.1.3 (known as the "Four Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.8.5.1.2 is necessary.

A.8.8.5.3 See A.8.5.5.3.

A.8.9.2.1 The protection area for extended coverage sidewall spray sprinklers is defined in the listing of the sprinkler as a

maximum square or rectangular area. Listing information is presented in even 2-ft (0.65-m) increments up to 28 ft (9 m) for extended coverage sidewall spray sprinklers. When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 14½ ft (4.4 m) wide and 20⅔ ft (6.3 m) long as indicated in Figure A.8.9.2.1, a sprinkler that is listed to protect an area of 16 ft × 22 ft (4.9 m × 6.7 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage.

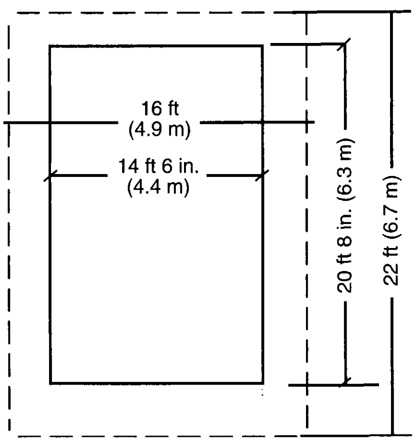


FIGURE A.8.9.2.1 Determination of Protection Area of Coverage for Extended Coverage Sidewall Sprinklers.

A.8.9.5.2.1.3 The rules of 8.9.5.2.1.3 (known as the "Four Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.9.5.1.2 is necessary.

A.8.9.5.3 See A.8.5.5.3.

A.8.10.6.2.1.3 The rules of 8.10.6.2.1.3 (known as the "Four Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.10.6.1.2 is necessary.

A.8.10.6.3 See A.8.5.5.3.

A.8.10.7.2.1.3 The rules of 8.10.7.2.1.3 (known as the "Four Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Four Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.10.6.1.2 is necessary.

A.8.10.7.3 See A.8.5.5.3.

A.8.11.2 Tests involving areas of coverage over 100 ft^2 (9.3 m^2) for large drop sprinklers are limited in number, and use of areas of coverage over 100 ft^2 (9.3 m^2) should be carefully considered.

A.8.11.3.1 It is important that sprinklers in the immediate vicinity of the fire center not skip, and this requirement imposes certain restrictions on the spacing.

A.8.11.4.1 If all other factors are held constant, the operating time of the first sprinkler will vary exponentially with the distance between the ceiling and deflector. At distances greater than 7 in. (178 mm), for other than open wood joist construction, the delayed operating time will permit the fire to gain headway, with the result that substantially more sprinklers operate. At distances less than 7 in. (178 mm), other effects occur. Changes in distribution, penetration, and cooling nullify the advantage gained by faster operation. The net result again is increased fire damage accompanied by an increase in the number of sprinklers operated. The optimum clearance between deflectors and ceiling is, therefore, 7 in. (178 mm). For open wood joist construction, the optimum clearance between deflectors and the bottom of joists is 3½ in. (89 mm).

A.8.11.5 To a great extent, large drop sprinklers rely on direct attack to gain rapid control of both the burning fuel and ceiling temperatures. Therefore, interference with the discharge pattern and obstructions to the distribution should be avoided.

A.8.11.5.2.1.3 The rules of 8.11.5.2.1.3 (known as the "Three Times Rule") have been written to apply to obstructions where the sprinkler can be expected to get water to both sides of the obstruction without allowing a significant dry shadow on the other side of the obstruction. This works for small noncontinuous obstructions and for continuous obstructions where the sprinkler can throw water over and under the obstruction, such as the bottom chord of an open truss or joist. For solid continuous obstructions, such as a beam, the Three Times Rule is ineffective since the sprinkler cannot throw water over and under the obstruction. Sufficient water must be thrown under the obstruction to adequately cover the floor area on the other side of the obstruction. To ensure this, compliance with the rules of 8.11.5.1.2 is necessary.

A.8.11.5.3 See A.8.5.5.3.

A.8.12.2.2.3 See Figure A.8.12.2.2.3.

A.8.12.3.1(3) See Figure A.8.12.2.2.3.

A.8.12.5.2 Isolated obstructions that block adjacent sprinklers in a similar manner should be treated as a continuous obstruction.

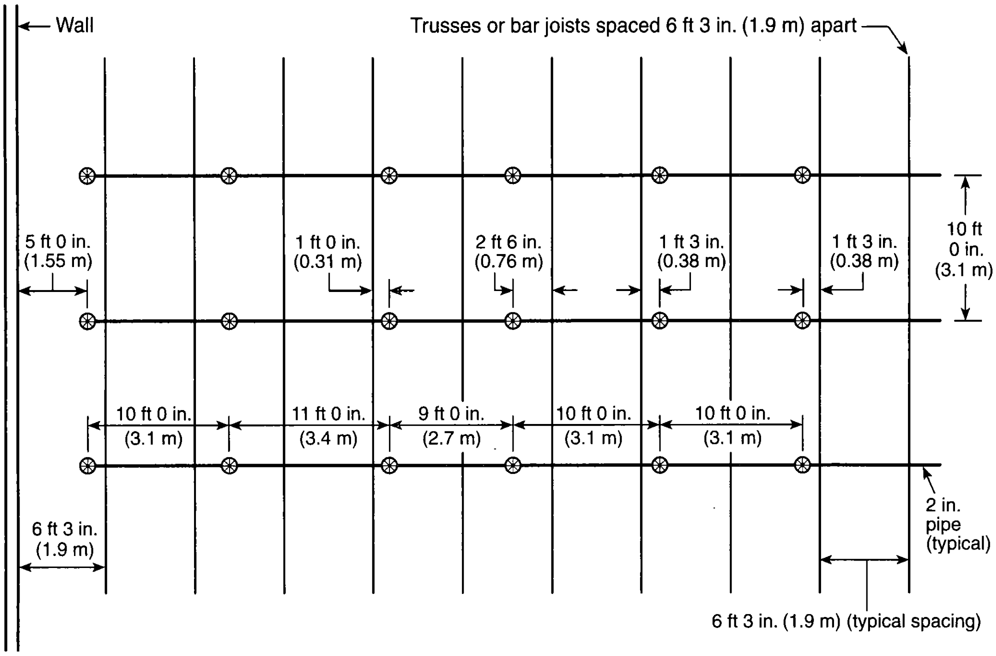


FIGURE A.8.12.2.2.3 ESFR Sprinkler Spacing Within Trusses and Bar Joists.

A.8.14.1.2 Subsections 8.14.1.2.3, 8.14.1.2.4, and 8.14.1.2.5 do not require sprinkler protection because it is not physically practical to install sprinklers in the types of concealed spaces discussed in these three exceptions. To reduce the possibility of uncontrolled fire spread, consideration should be given in these unsprinklered concealed space situations to using 8.14.1.2.7, 8.14.1.2.10, and 8.14.1.2.12.

A.8.14.1.2.6 See Figure A.8.14.1.2.6.

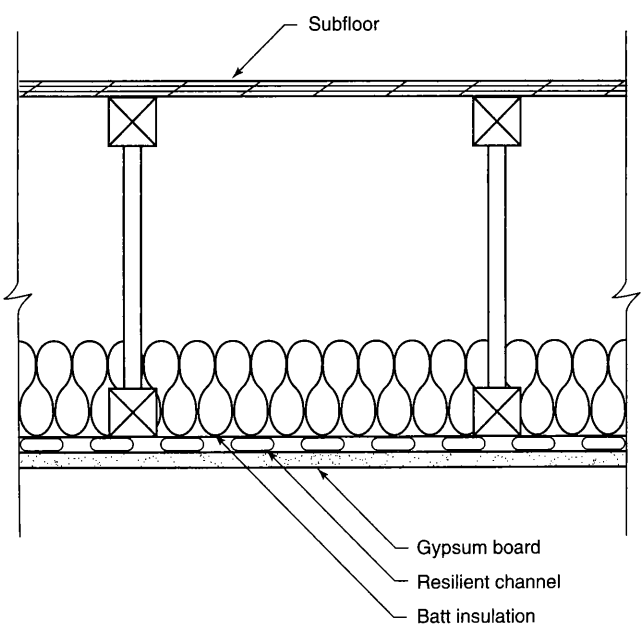


FIGURE A.8.14.1.2.6 Combustible Concealed Space Cross Section.

A.8.14.1.6 Surfaces should be considered to channel heat when the surface or supporting members are greater than 2 in. in depth.

A.8.14.2.2 Where practicable, sprinklers should be staggered at the alternate floor levels, particularly where only one sprinkler is installed at each floor level.

A.8.14.3.3 See Figure A.8.14.3.3(a) and Figure A.8.14.3.3(b). Sprinklers would be required in the case shown in Figure A.8.14.3.3(a) but not in the case shown in Figure A.8.14.3.3(b).

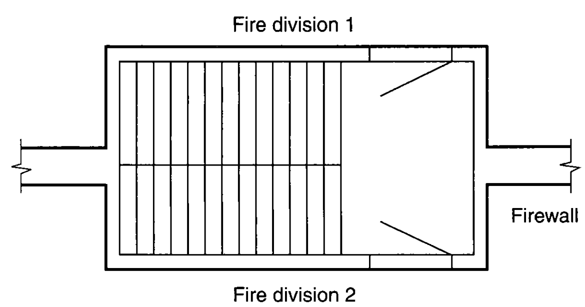


FIGURE A.8.14.3.3(a) Noncombustible Stair Shaft Serving Two Fire Sections.

A.8.14.4 Where sprinklers in the normal ceiling pattern are closer than 6 ft (1.8 m) from the water curtain, it might be preferable to locate the water curtain sprinklers in recessed baffle pockets. *(See Figure A.8.14.4.)*

A.8.14.4.5(2) Subsection 8.2.5.4 of the 2000 edition of NFPA *101*,® *Life Safety Code*® requires a 2-hour separation for enclosures connecting four stories or more in new construction, a 1-hour separation for other enclosures in new construction, and a 30-minute separation for existing buildings. Special rules for residential construction exist in Chapters 26 through 31 of NFPA *101*.

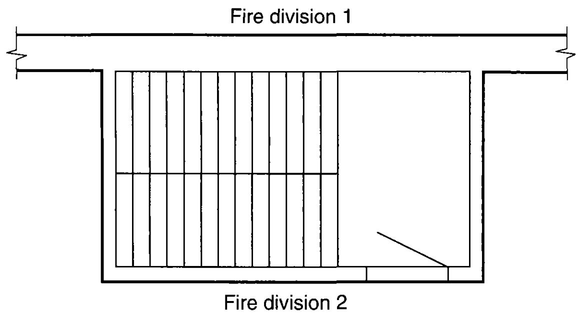


FIGURE A.8.14.3.3(b) Noncombustible Stair Shaft Serving One Fire Section.

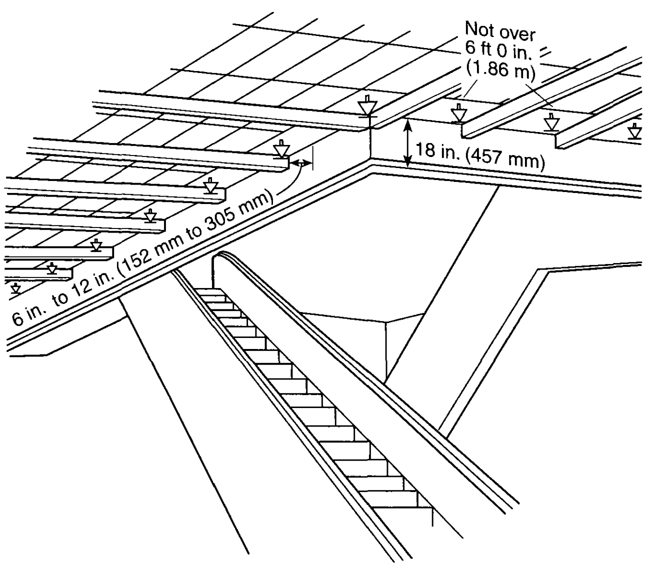


FIGURE A.8.14.4 Sprinklers Around Escalators.

A.8.14.5.1 The sprinklers in the pit are intended to protect against fires cause by debris, which can accumulate over time. Ideally, the sprinklers should be located near the side of the pit below the elevator doors, where most debris accumulates. However, care should be taken that the sprinkler location does not interfere with the elevator toe guard, which extends below the face of the door opening.

ASME A17.1, *Safety Code for Elevators and Escalators,* allows the sprinklers within 2 ft (0.65 m) of the bottom of the pit to be exempted from the special arrangements of inhibiting waterflow until elevator recall has occurred.

A.8.14.5.3 ASME A17.1, *Safety Code for Elevators and Escalators,* requires the shutdown of power to the elevator upon or prior to the application of water in elevator machine rooms or hoistways. This shutdown can be accomplished by a detection system with sufficient sensitivity that operates prior to the activation of the sprinklers *(see also NFPA 72®, National Fire Alarm Code®).* As an alternative, the system can be arranged using devices or sprinklers capable of effecting power shutdown immediately upon sprinkler activation, such as a waterflow switch without a time delay. This alternative arrangement is intended to interrupt power before significant sprinkler discharge.

A.8.14.5.4 Passenger elevator cars that have been constructed in accordance with ASME A17.1, *Safety Code for Elevators and Escalators,* Rule 204.2a (under A17.1a-1985 and later editions of the code) have limited combustibility. Materials exposed to the interior of the car and the hoistway, in their end-use composition, are limited to a flame spread rating of 0 to 75 and a smoke development rating of 0 to 450.

A.8.14.7 Small loading docks, covered platforms, ducts, or similar small unheated areas can be protected by dry-pendent sprinklers extending through the wall from wet sprinkler piping in an adjacent heated area. Where protecting covered platforms, loading docks, and similar areas, a dry-pendent sprinkler should extend down at a 45-degree angle. The width of the area to be protected should not exceed 7½ ft (2.3 m). Sprinklers should be spaced not over 12 ft (3.7 m) apart. *(See Figure A.8.14.7.)*

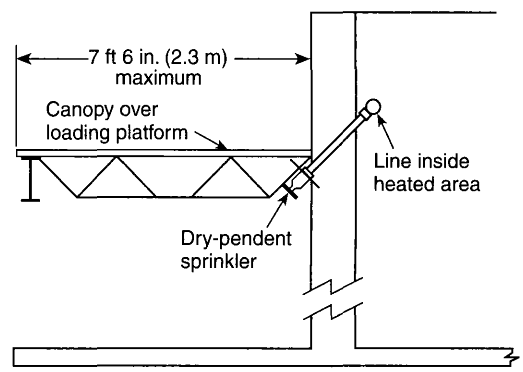


FIGURE A.8.14.7 Dry-Pendent Sprinklers for Protection of Covered Platforms, Loading Docks, and Similar Areas.

A.8.14.7.1 Balconies, decks, and similar projections from the building should be treated as exterior roofs and canopies when applying the criteria of 8.14.7.1.

A.8.14.7.4 Short-term transient storage, such as that for delivered packages, and the presence of planters, newspaper machines, and so forth, should not be considered storage or handling of combustibles.

A.8.14.8.2 Portable wardrobe units, such as those typically used in nursing homes and mounted to the wall, do not require sprinklers to be installed in them. Although the units are attached to the finished structure, this standard views those units as pieces of furniture rather than as a part of the structure; thus, sprinklers are not required.

A.8.14.11 The combustible materials present inside industrial ovens and furnaces can be protected by automatic sprinklers. Wet sprinkler systems are preferred. However, water-filled piping exposed to heat within an oven or furnace can incur deposition and buildup of minerals within the pipe. If the oven or furnace could be exposed to freezing temperatures, dry-pendent sprinklers are an alternative to wet pipe systems. Another option is to use a dry pipe system.

The preferred arrangement for piping is outside of the oven; the sprinkler should be installed in the pendent position. The sprinkler temperature rating should be at least 50°F (28°C) greater than the high-temperature limit setting of the oven or applicable zone. As a minimum, the sprinkler system inside the oven or furnace should be designed to provide 15 psi (1 bar) with

all sprinklers operating inside the oven/furnace. Sprinkler spacing on each branch line should not exceed 12 ft (3.7 m).

A.8.14.12 The installation of open-grid egg crate, louver, or honeycomb ceilings beneath sprinklers restricts the sideways travel of the sprinkler discharge and can change the character of discharge.

A.8.14.13.4 Drop-out ceilings do not provide the required protection for soft-soldered copper joints or other piping that requires protection.

A.8.14.13.5 The ceiling tiles might drop before sprinkler operation. Delayed operation might occur because heat must then bank down from the deck above before sprinklers will operate.

A.8.14.14.2 For tests of sprinkler performance in fur vaults see "Fact Finding Report on Automatic Sprinkler Protection for Fur Storage Vaults" of Underwriters Laboratories Inc., dated November 25, 1947.

Sprinklers should be listed old-style with orifice sizes selected to provide a flow rate as close as possible to, but not less than, 20 gpm (76 L/min) per sprinkler, for four sprinklers, based on the water pressure available.

Sprinklers in fur storage vaults should be located centrally over the aisles between racks and should be spaced not over 5 ft (1.5 m) apart along the aisles.

Where sprinklers are spaced 5 ft (1.5 m) apart along the sprinkler branch lines, pipe sizes should be in accordance with the following schedule:

1 in. (25.4 mm) — 4 sprinklers
1¼ in. (31.8 mm) — 6 sprinklers
1½ in. (38.1 mm) — 10 sprinklers
2 in. (51 mm) — 20 sprinklers
2½ in. (63.5 mm) — 40 sprinklers
3 in. (76.2 mm) — 80 sprinklers

A.8.14.19.1 Outlets meeting the requirements of this standard should be provided in anticipation of the final finished area.

A.8.14.21 See Figure A.8.14.21.

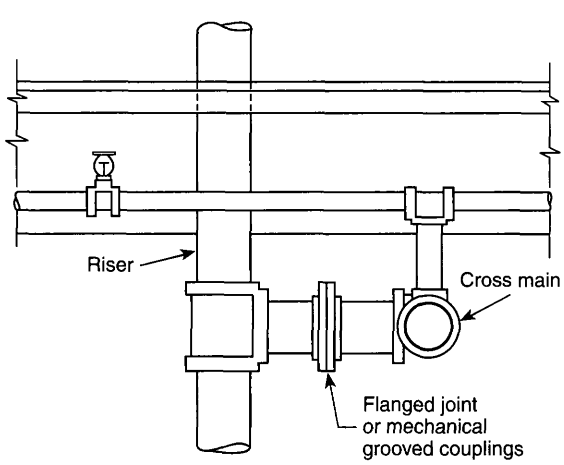


FIGURE A.8.14.21 One Arrangement of Flanged Joint at Sprinkler Riser.

A.8.15.1.1 See Figure A.8.15.1.1.

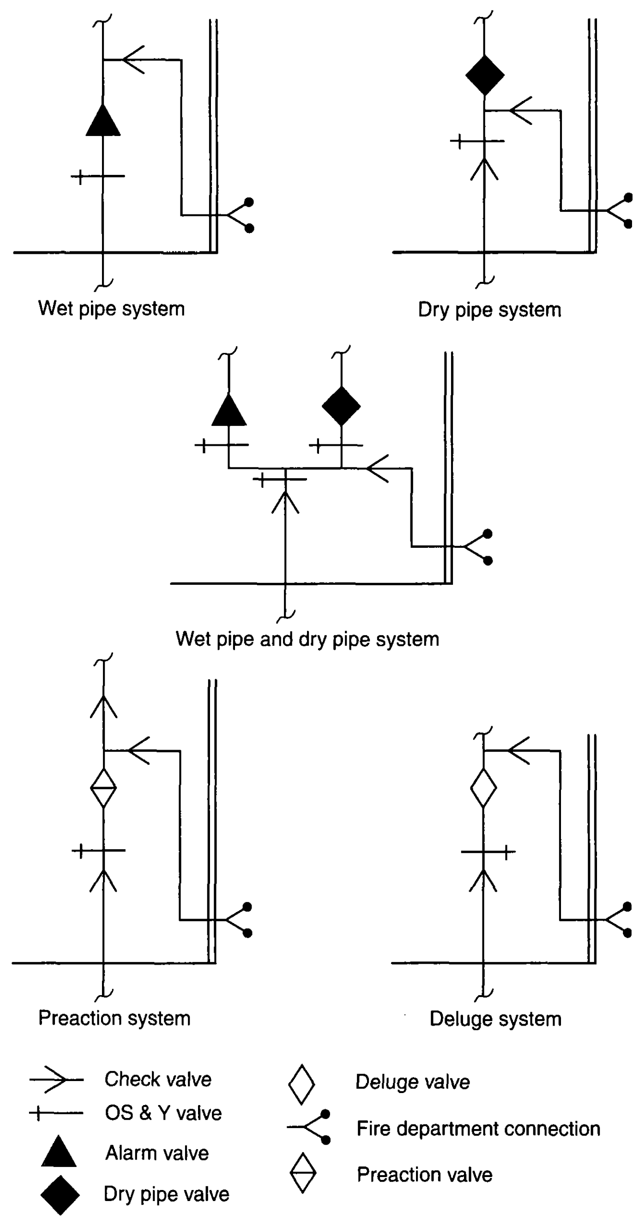


FIGURE A.8.15.1.1 Examples of Acceptable Valve Arrangements.

A.8.15.1.1.1 A water supply connection should not extend into a building or through a building wall unless such connection is under the control of an outside listed indicating valve or an inside listed indicating valve located near the outside wall of the building.

All valves controlling water supplies for sprinkler systems or portions thereof, including floor control valves, should be accessible to authorized persons during emergencies. Permanent ladders, clamped treads on risers, chain-operated hand wheels, or other accepted means should be provided where necessary.

Outside control valves are suggested in the following order of preference:

(1) Listed indicating valves at each connection into the building at least 40 ft (12.2 m) from buildings if space permits

(2) Control valves installed in a cutoff stair tower or valve room accessible from outside
(3) Valves located in risers with indicating posts arranged for outside operation.
(4) Key-operated valves in each connection into the building

A.8.15.1.1.2 The management is responsible for the supervision of valves controlling water supply for fire protection and should exert every effort to see that the valves are maintained in the normally open position. This effort includes special precautions to ensure that protection is promptly restored by completely opening valves that are necessarily closed during repairs or alterations. The precautions apply equally to valves controlling sprinklers and other fixed water-based fire suppression systems, hydrants, tanks, standpipes, pumps, street connections, and sectional valves.

Either one or a combination of the methods of valve supervision described in the following list is considered essential to ensure that the valves controlling fire protection systems are in the normally open position. The methods described are intended as an aid to the person responsible for developing a systematic method of determining that the valves controlling sprinkler systems and other fire protection devices are open.

Continual vigilance is necessary if valves are to be kept in the open position. Responsible day and night employees should be familiar with the location of all valves and their proper use.

The authority having jurisdiction should be consulted as to the type of valve supervision required. Contracts for equipment should specify that all details are to be subject to the approval of the authority having jurisdiction.

(1) *Central Station Supervisory Service.* Central station supervisory service systems involve complete, constant, and automatic supervision of valves by electrically operated devices and circuits continually under test and operating through an approved outside central station, in compliance with *NFPA 72, National Fire Alarm Code.* It is understood that only such portions of *NFPA 72* that relate to valve supervision should apply.
(2) *Proprietary Supervisory Service Systems.* Proprietary supervisory service systems include systems where the operation of a valve produces some form of signal and record at a common point by electrically operated devices and circuits continually under test and operating through a central supervising station at the property protected, all in compliance with the standards for the installation, maintenance, and use of local protective, auxiliary protective, remote station protective, and proprietary signaling systems. It is understood that only portions of the standards that relate to valve supervision should apply.

The standard method of locking, sealing, and tagging valves to prevent, so far as possible, their unnecessary closing, to obtain notification of such closing, and to aid in restoring the valve to normal condition is a satisfactory alternate to valve supervision. The authority having jurisdiction should be consulted as to details for specific cases.

Where electrical supervision is not provided, locks or seals should be provided on all valves and should be of a type acceptable to the authority having jurisdiction.

Seals can be marked to indicate the organization under whose jurisdiction the sealing is conducted. All seals should be attached to the valve in such a manner that the valves cannot be operated without breaking the seals. Seals should be of a character to prevent injury in handling and to prevent reassembly when broken. When seals are used, valves should be inspected weekly. The authority having jurisdiction can require a valve tag to be used in conjunction with the sealing.

A padlock, with a chain where necessary, is especially desirable to prevent unauthorized closing of valves in areas where valves are subject to tampering. When such locks are employed, valves should be inspected monthly.

If valves are locked, any distribution of keys should be restricted to only those directly responsible for the fire protection system. Multiple valves should not be locked together; they should be individually locked.

The individual performing the inspections should determine that each valve is in the normal position, properly locked or sealed, and so note on an appropriate record form while still at the valve. The authority having jurisdiction should be consulted for assistance in preparing a suitable report form for this activity.

Identification signs should be provided at each valve to indicate its function and what it controls.

The position of the spindle of OS&Y valves or the target on the indicator valves cannot be accepted as conclusive proof that the valve is fully open. The opening of the valve should be followed by a test to determine that the operating parts have functioned properly.

The test consists of opening the main drain valve and permitting free flow of water until the gauge reading becomes stationary. If the pressure drop is excessive for the water supply involved, the cause should be determined immediately and the proper remedies taken. When sectional valves or other special conditions are encountered, other methods of testing should be used.

If it becomes necessary to break a seal for emergency reasons, the valve, following the emergency, should be opened by the person responsible for the fire protection of the plant, or his or her designated representative, and this person should apply a seal at the time of the valve opening. This seal should be maintained in place until such time as the authority having jurisdiction can replace it with one of its own.

Seals or locks should not be applied to valves reopened after closure until such time as the inspection procedure is carried out.

Where water is shut off to the sprinkler or other fixed water-based fire suppression systems, a guard or other qualified person should be placed on duty and required to continuously patrol the affected sections of the premises until such time as protection is restored.

During specific critical situations, a person should be stationed at the valve so that the valve can be reopened promptly if necessary. It is the intent of this section that the person remain within sight of the valve and have no other duties beyond this responsibility. This procedure is considered imperative when fire protection is shut off immediately following a fire.

An inspection of all other fire protection equipment should be made prior to shutting off water in order to make sure it is in operative condition.

In case of changes to fire protection equipment, all possible work should be done in advance of shutting off the water so that final connections can be made quickly and protection restored promptly. Many times it will be found that by careful planning open outlets can be plugged and protection restored on a portion of the equipment while the alterations are being made.

Where changes are being made in underground piping, all possible piping should be laid before shutting off the water for

final connections. Where possible, temporary feed lines, such as temporary piping for reconnection of risers by hose lines, and so forth, should be used to afford maximum protection. The plant, public fire department, and other authorities having jurisdiction should be notified of all impairments to fire protection equipment.

A.8.15.1.1.3.5 Where a system having only one dry pipe valve is supplied with city water and a fire department connection, it will be satisfactory to install the main check valve in the water supply connection immediately inside of the building. In instances where there is no outside control valve, the system indicating valve should be placed at the service flange, on the supply side of all fittings.

A.8.15.1.1.4 See Figure A.8.15.1.1.4. For additional information on controlling valves, see NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

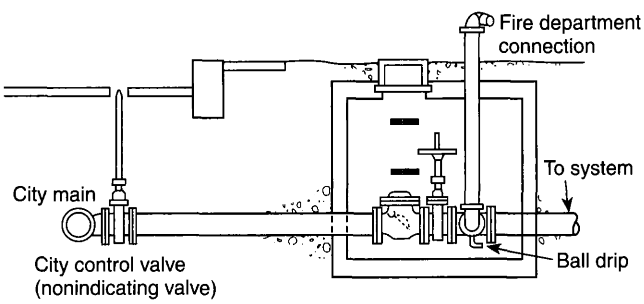


FIGURE A.8.15.1.1.4 Pit for Gate Valve, Check Valve, and Fire Department Connection.

A.8.15.1.1.5 For additional information on controlling valves, see NFPA 22, *Standard for Water Tanks for Private Fire Protection.*

A.8.15.1.1.6 Check valves on tank or pump connections, when located underground, can be placed inside of buildings and at a safe distance from the tank riser or pump, except in cases where the building is entirely of one fire area, when it is ordinarily considered satisfactory to locate the check valve overhead in the lowest level.

A.8.15.1.1.7 It might be necessary to provide valves located in pits with an indicator post extending above grade or other means so that the valve can be operated without entering the pit.

A.8.15.1.2.3 Where the relief valve operation would result in water being discharged onto interior walking or working surfaces, consideration should be given to piping the discharge from the valve to a drain connection or other safe location.

A.8.15.1.3 Outside control valves are suggested in the following order of preference:

(1) Listed indicating valves at each connection into the building at least 40 ft (12.2 m) from buildings if space permits
(2) Control valves installed in a cutoff stair tower or valve room accessible from outside
(3) Valves located in risers with indicating posts arranged for outside operation
(4) Key-operated valves in each connection into the building

Post-indicator valves should be located not less than 40 ft (12.2 m) from buildings. When post-indicator valves cannot be placed at this distance, they are permitted to be located closer, or wall post-indicator valves can be used, provided they are set in locations by blank walls where the possibility of injury by falling walls is unlikely and from which people are not likely to be driven by smoke or heat. Usually, in crowded plant yards, they can be placed beside low buildings, near brick stair towers, or at angles formed by substantial brick walls that are not likely to fall.

A.8.15.1.4.2 A valve wrench with a long handle should be provided at a convenient location on the premises.

A.8.15.1.6 In-rack sprinklers and ceiling sprinklers selected for protection should be controlled by at least two separate indicating valves and drains. In higher rack arrangements, consideration should be given to providing more than one in-rack control valve in order to limit the extent of any single impairment.

A.8.15.2.1 All piping should be arranged where practicable to drain to the main drain valve.

A.8.15.2.4 Figure A.8.15.2.4 is an example of an unacceptable arrangement, because it will not give a true residual reading, it will indicate an excessive pressure drop.

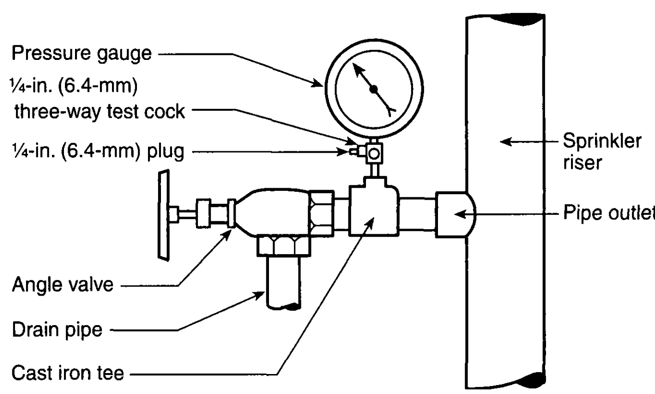


FIGURE A.8.15.2.4 Unacceptable Pressure Gauge Location.

A.8.15.2.5.2.1 An example of an accessible location would be a valve located approximately 7 ft (2 m) above the floor level to which a hose could be connected to discharge the water in an acceptable manner.

A.8.15.2.6.1 Where possible, the main sprinkler riser drain should discharge outside the building at a point free from the possibility of causing water damage. Where it is not possible to discharge outside the building wall, the drain should be piped to a sump, which in turn should discharge by gravity or be pumped to a waste water drain or sewer. The main sprinkler riser drain connection should be of a size sufficient to carry off water from the fully open drain valve while it is discharging under normal water system pressures. Where this is not possible, a supplementary drain of equal size should be provided for test purposes with free discharge, located at or above grade.

A.8.15.3.1.3 Branch lines have been intentionally left out of this paragraph as it is an unacceptable practice to heat trace and insulate branch lines.

A.8.15.3.2.1 Types of locations where corrosive conditions can exist include bleacheries, dye houses, metal plating processes, animal pens, and certain chemical plants.

If corrosive conditions are not of great intensity and humidity is not abnormally high, good results can be obtained by a protective coating of red lead and varnish or by a good grade of commercial acid-resisting paint. The paint manufacturer's instructions should be followed in the preparation of the surface and in the method of application.

Where moisture conditions are severe but corrosive conditions are not of great intensity, copper tube or galvanized steel pipe, fittings, and hangers might be suitable. The exposed threads of steel pipe should be painted.

In instances where the piping is not readily accessible and where the exposure to corrosive fumes is severe, either a protective coating of high quality can be employed or some form of corrosion-resistant material used.

A.8.16.1 Central station, auxiliary, remote station, or proprietary protective signaling systems are a highly desirable supplement to local alarms, especially from a safety to life standpoint. *(See 8.16.1.6.)*

Approved identification signs, as shown in Figure A.8.16.1, should be provided for outside alarm devices. The sign should be located near the device in a conspicuous position and should be worded as follows:

SPRINKLER FIRE ALARM — WHEN BELL RINGS
CALL FIRE DEPARTMENT OR POLICE.

FIGURE A.8.16.1 Identification Sign.

A.8.16.1.5 Water motor-operated devices should be located as near as practicable to the alarm valve, dry pipe valve, or other waterflow detecting device. The total length of the pipe to these devices should not exceed 75 ft (22.9 m), nor should the water motor-operated device be located over 20 ft (6.1 m) above the alarm device or dry pipe valve.

A.8.16.1.6 Monitoring should include but not be limited to control valves, building temperatures, fire pump power supplies and running conditions, and water tank levels and temperatures. Pressure supervision should also be provided on pressure tanks.

Check valves can be required to prevent false waterflow signals on floors where sprinklers have not activated — for example, floor systems interconnected to two supply risers.

A.8.16.1.7 For further information, see *NFPA 72, National Fire Alarm Code.*

A.8.16.2 The fire department connection should be located not less than 18 in. (457 mm) and not more than 4 ft (1.2 m) above the level of the adjacent grade or access level.

Typical fire department connections are shown in Figure A.8.16.2(a) and Figure A.8.16.2(b). See NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems.*

A.8.16.2.1 Fire department connections should be located and arranged so that hose lines can be readily and conveniently attached without interference from nearby objects including buildings, fences, posts, or other fire department connections. Where a hydrant is not available, other water supply sources such as a natural body of water, a tank, or reservoir should be utilized. The water authority should be consulted when a nonpotable water supply is proposed as a suction source for the fire department.

A.8.16.2.4 The check valve should be located to maximize accessibility and minimize freezing potential.

A.8.16.2.4.1 The fire department connection should be connected to the system riser. For single systems it is an acceptable arrangement to attach the fire department connection to any point in the system provided the pipe size meets the requirements of 8.16.2.3.

A.8.16.4.1 See Figure A.8.16.4.1.

A.8.16.4.2 This test connection should be in the upper story, and the connection preferably should be piped from the end of the most remote branch line. The discharge should be at a point where it can be readily observed. In locations where it is not practical to terminate the test connection outside the building, the test connection is permitted to terminate into a drain capable of accepting full flow under system pressure. In this event, the test connection should be made using an approved sight test connection containing a smooth bore corrosion-resistant orifice giving a

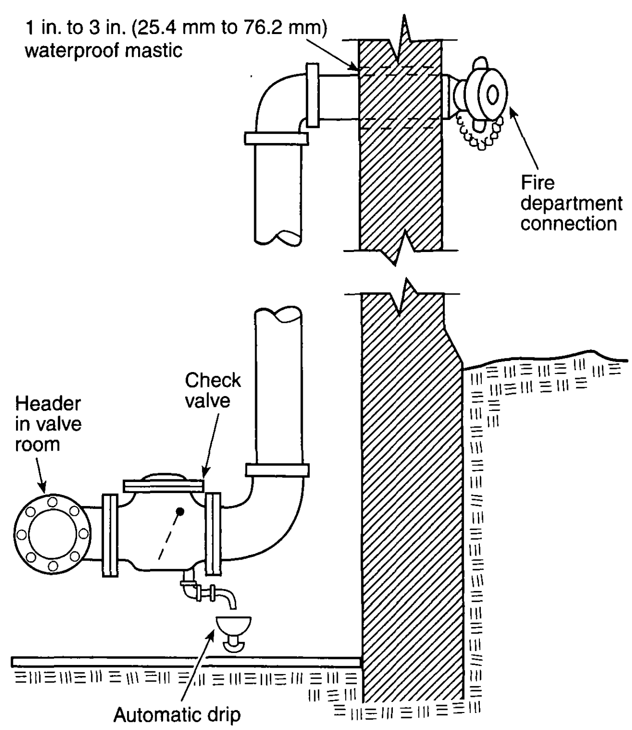
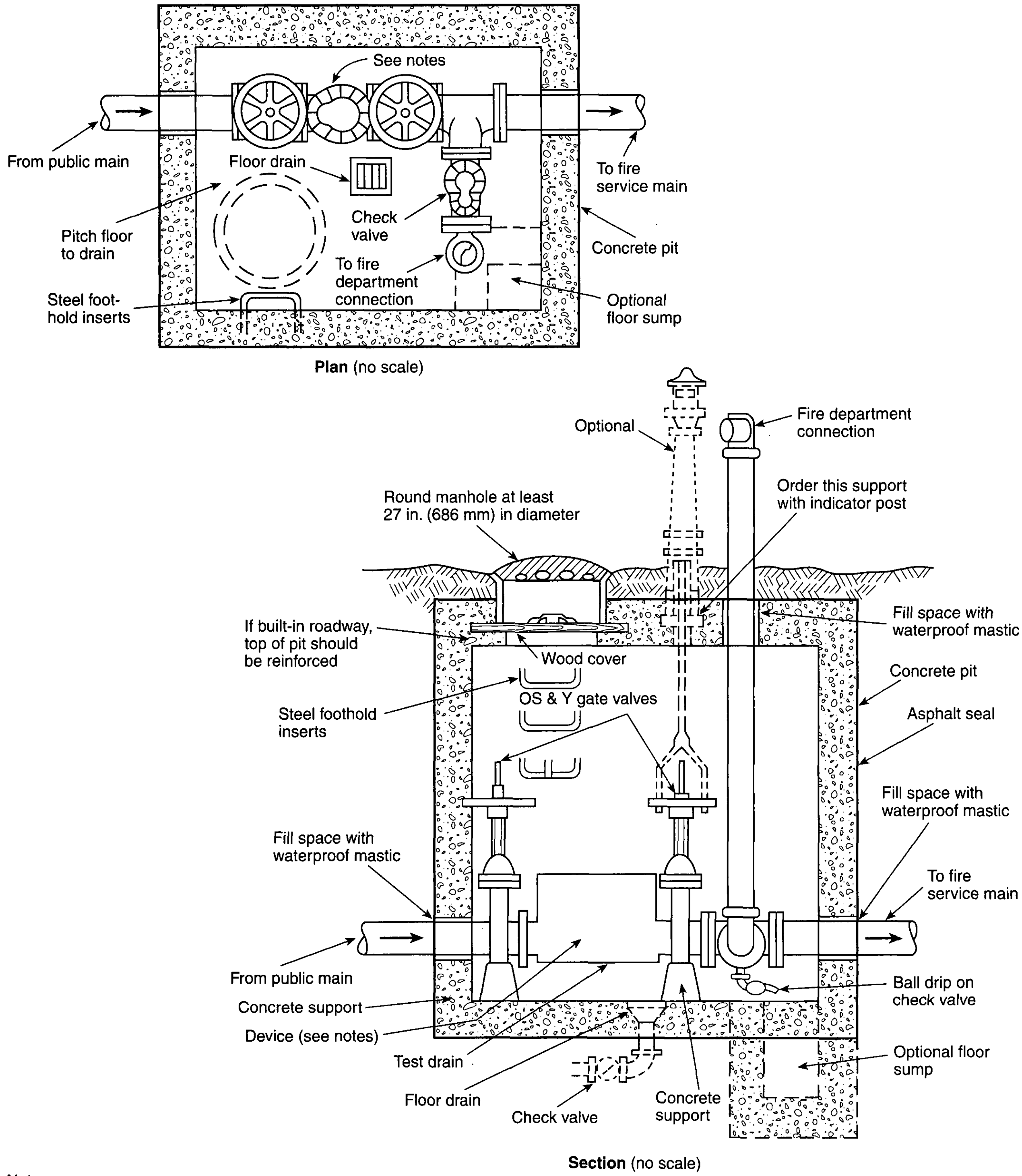


FIGURE A.8.16.2(a) Fire Department Connection.



Notes:

1. Various backflow prevention regulations accept different devices at the connection between public water mains and private fire service mains.
2. The device shown in the pit could be any or a combination of the following:
   (a) Gravity check valve
   (b) Detector check vlave
   (c) Double check valve assembly
   (d) Reduced pressure zone (RPZ) device
   (e) Vacuum breaker
3. Some backflow prevention regulations prohibit these devices from being installed in a pit.
4. In all cases, the device(s) in the pit should be approved or listed as necessary. The requirements of the local or municipal water department should be reviewed prior to design or installation of the connection.
5. Pressure drop should be considered prior to the installation of any backflow prevention devices.

FIGURE A.8.16.2(b) Typical City Water Pit — Valve Arrangement.

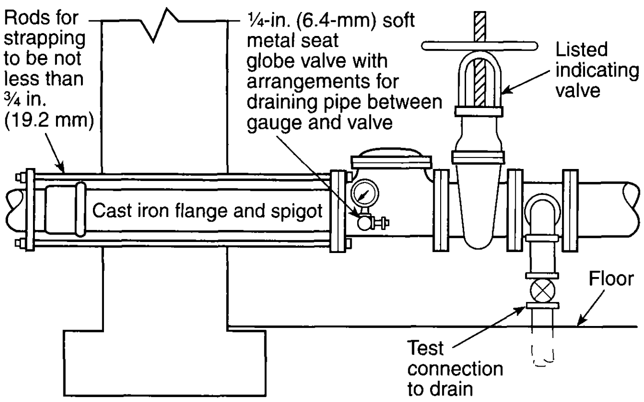
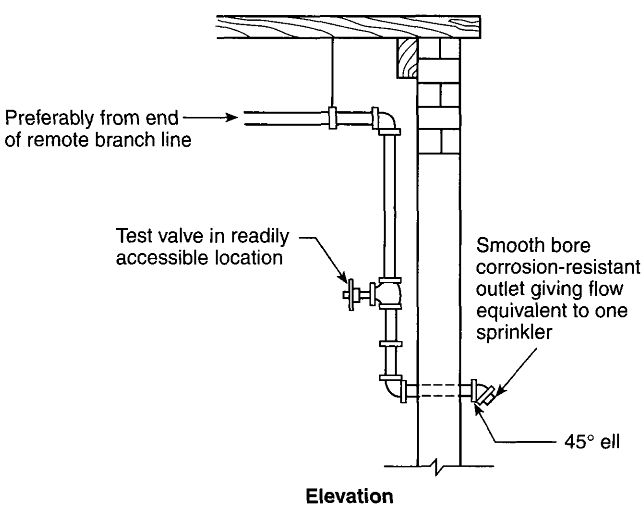


FIGURE A.8.16.4.1 Water Supply Connection with Test Connection.

flow equivalent to one sprinkler simulating the least flow from an individual sprinkler in the system. *[See Figure A.8.16.4.2(a) and Figure A.8.16.4.2(b).]* The test valve should be located at an accessible point and preferably not over 7 ft (2.1 m) above the floor. The control valve on the test connection should be located at a point not exposed to freezing.



Note: Not less than 4 ft (1.2 m) of exposed test pipe in warm room beyond valve where pipe extends through wall to outside.

FIGURE A.8.16.4.2(a) System Test Connection on Wet Pipe System.

A.8.16.4.3 See Figure A.8.16.4.3.

A.8.16.4.6 Where backflow prevention devices are installed, they should be in an accessible location to provide for service and maintenance.

A.8.16.4.6.1 The full flow test of the backflow prevention valve can be performed with a test header or other connection downstream of the valve. A bypass around the check valve in the fire department connector line with a control valve in the normally closed position can be an acceptable arrangement. When flow to a visible drain cannot be accomplished, closed loop flow can be acceptable if a flow meter or site glass is incorporated into the system to ensure flow. When a backflow prevention device is retroactively installed on a pipe schedule system, the revised hydraulic calculation still follows the pipe schedule method of 11.2.2 with the inclusion of friction loss for the device.

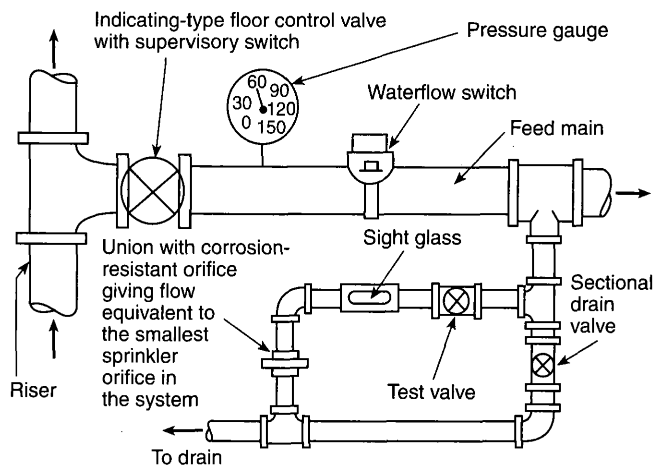
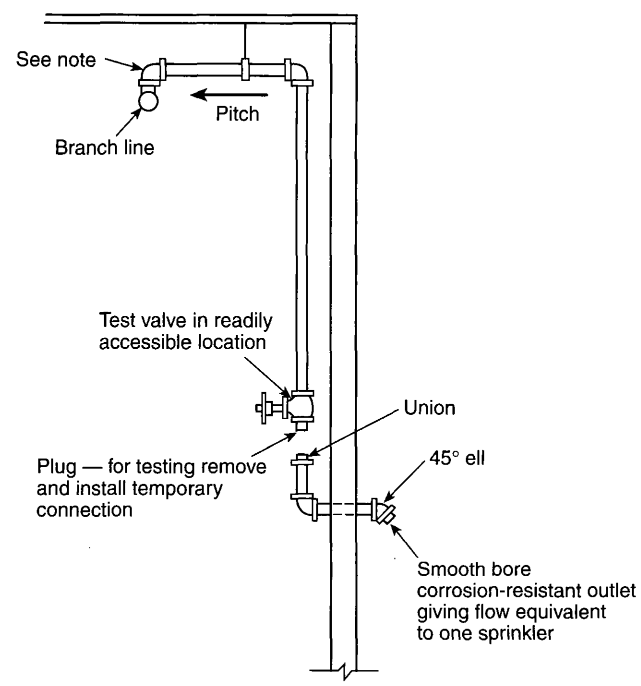


FIGURE A.8.16.4.2(b) Floor Control Valve.



Note: To minimize condensation of water in the drop to the test connection, provide a nipple-up off of the branch line.

FIGURE A.8.16.4.3 System Test Connection on Dry Pipe System.

A.8.16.5.1.1 In areas used to store baled cotton, due consideration to access aisle configuration should be given with maximum hose lengths not exceeding 100 ft (30.1 m). Additionally, in these areas, where a separate piping system is used to supply hose lines it should be in accordance with NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.*

A.8.16.5.1.4 This standard covers 1½-in. (38-mm) hose connections for use in storage occupancies and other locations where

standpipe systems are not required. Where Class II standpipe systems are required, see the appropriate provisions of NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* with respect to hose stations and water supply for hose connections from sprinkler systems.

A.8.16.5.2 Combined automatic sprinkler and standpipe risers should not be interconnected by sprinkler system piping.

A.9.1.1 See Figure A.9.1.1.

A.9.1.1.6 Table 9.1.1.6.1(b) assumes that the load from 15 ft (5 m) of water-filled pipe, plus 250 lb (114 kg), is located at the midpoint of the span of the trapeze member, with a maximum allowable bending stress of 15 ksi (111 kg). If the load is applied at other than the midpoint, for the purpose of sizing the trapeze member, an equivalent length of trapeze can be used, derived from the following formula:

$$L = \frac{4ab}{a+b}$$

where:
L = equivalent length
a = distance from one support to the load
b = distance from the other support to the load

Where multiple mains are to be supported or multiple trapeze hangers are provided in parallel, the required or available section modulus can be added.

A.9.1.1.7 The rules covering the hanging of sprinkler piping take into consideration the weight of water-filled pipe plus a safety factor. No allowance has been made for the hanging of nonsystem components from sprinkler piping. NFPA 13 provides the option to support sprinkler piping from other sprinkler piping where the requirements of 9.1.1.2 are met.

A.9.1.3.9.3 The ability of concrete to hold the studs varies widely according to type of aggregate, quality of concrete, and proper installation.

A.9.1.4.1 Powder-driven studs should not be used in steel of less than 3⁄16 in. (4.8 mm) total thickness.

A.9.2.1.3 The method used to attach the hanger to the structure and the load placed on the hanger should take into account any limits imposed by the structure. Design manual information for pre-engineered structures or other specialty construction materials should be consulted, if appropriate.

System mains hung to a single beam, truss, or purlin can affect the structural integrity of the building by introducing excessive loads not anticipated in the building design. Also, special conditions such as collateral and concentrated load limits, type or method of attachment to the structural components, or location of attachment to the structural components might need to be observed when hanging system piping in pre-engineered metal buildings or buildings using other specialty structural components such as composite wood joists or combination wood and tubular metal joists.

A.9.2.2 Where copper tube is to be installed in moist areas or other environments conducive to galvanic corrosion, copper hangers or ferrous hangers with an insulating material should be used.

A.9.2.3.2.2 See Figure A.9.2.3.2.2.

A.9.2.3.4 Sprinkler piping should be adequately secured to restrict the movement of piping upon sprinkler operation. The reaction forces caused by the flow of water through the sprinkler could result in displacement of the sprinkler, thereby adversely affecting sprinkler discharge. Listed CPVC pipe and listed polybutylene pipe have specific requirements for piping support to include additional pipe bracing of sprinklers. See Figure A.9.2.3.4.

A.9.2.3.4.3 See Figure A.9.2.3.4.3(a) and Figure A.9.2.3.4.3(b).

A.9.2.3.5 See Figure A.9.2.3.5.

A.9.2.3.5.2 See Figure A.9.2.3.5.2.

A.9.3.1 Sprinkler systems are protected against earthquake damage by means of the following:

(1) Stresses that would develop in the piping due to differential building movement are minimized through the use of flexible joints or clearances.
(2) Bracing is used to keep the piping fairly rigid when supported from a building component expected to move as a unit, such as a ceiling.

Areas known to have a potential for earthquakes have been identified in building code and insurance maps. Examples of two such maps are shown in Figure A.9.3.1(a) and Figure A.9.3.1(b).

A.9.3.2 Strains on sprinkler piping can be greatly lessened and, in many cases, damage prevented by increasing the flexibility between major parts of the sprinkler system. One part of the piping should never be held rigidly and another part allowed to move freely without provision for relieving the strain. Flexibility can be provided by using listed flexible couplings, by joining grooved end pipe at critical points, and by allowing clearances at walls and floors.

Tank or pump risers should be treated the same as sprinkler risers for their portion within a building. The discharge pipe of tanks on buildings should have a control valve above the roof line so any pipe break within the building can be controlled.

Piping 2 in. (51 mm) or smaller in size is pliable enough so that flexible couplings are not usually necessary. "Rigid-type" couplings that permit less than 1 degree of angular movement at the grooved connections are not considered to be flexible couplings. *[See Figure A.9.3.2(a) and Figure A.9.3.2(b).]*

A.9.3.2.3(2) The flexible coupling should be at the same elevation as the flexible coupling on the main riser. *[See Figure A.9.3.2.3(2).]*

A.9.3.2.3(4) A building expansion joint is usually a bituminous fiber strip used to separate blocks or units of concrete to prevent cracking due to expansion as a result of temperature changes. Where building expansion joints are used, the flexible coupling is required on one side of the joint by 9.3.2.3(4).

For seismic separation joints, considerably more flexibility is needed, particularly for piping above the first floor. Figure A.9.3.3 shows a method of providing additional flexibility through the use of swing joints.

A.9.3.3 Plan and elevation views of a seismic separation assembly assembled with flexible elbows are shown in Figure A.9.3.3.

A seismic separation assembly is considered to be an assembly of fittings, pipe, and couplings or an assembly of pipe and couplings that permits movement in all directions. The extent of permitted movement should be sufficient to accommodate calculated differential motions during earthquakes. In lieu of calculations, permitted movement can be made at least twice the actual separations, at right angles to the separation as well as parallel to it.

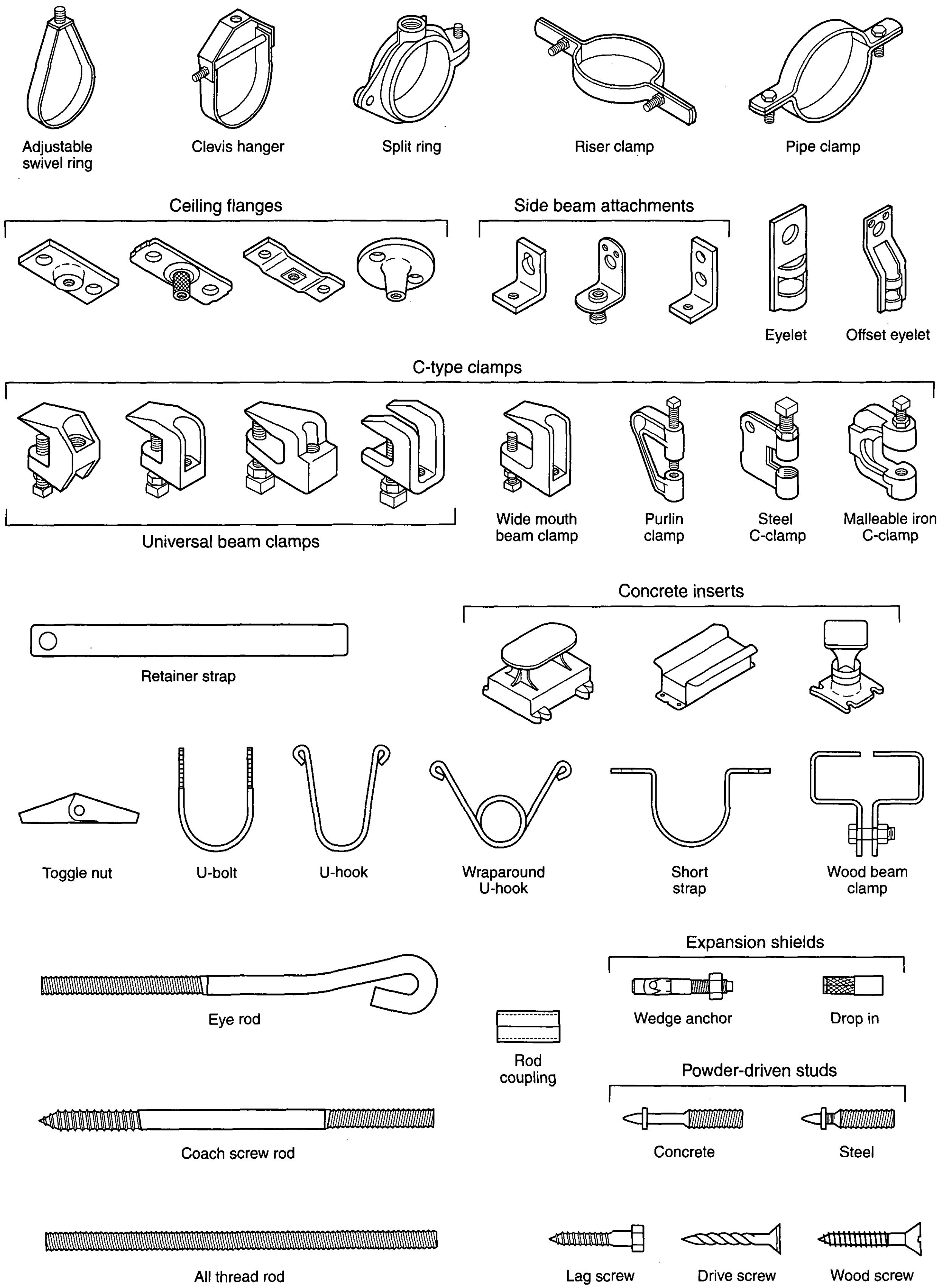


FIGURE A.9.1.1 Common Types of Acceptable Hangers.

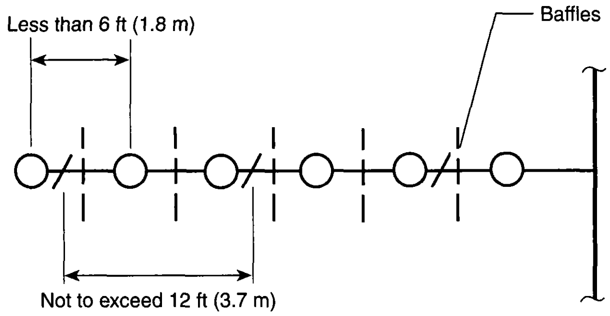


FIGURE A.9.2.3.2.2 Distance Between Hangers.

A.9.3.4 While clearances are necessary around the sprinkler piping to prevent breakage due to building movement, suitable provision should also be made to prevent passage of water, smoke, or fire.

Drains, fire department connections, and other auxiliary piping connected to risers should not be cemented into walls or floors; similarly, pipes that pass horizontally through walls or foundations should not be cemented solidly or strains will accumulate at such points.

Where risers or lengths of pipe extend through suspended ceilings, they should not be fastened to the ceiling framing members.

A.9.3.5 Figure A.9.3.5(a) and Figure A.9.3.5(b) are examples of forms used to aid in the preparation of bracing calculations.

A.9.3.5.2.2 The investigation of tension-only bracing using materials, connection methods, or both, other than those described in Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c), should involve consideration of the following:

(1) Corrosion resistance.
(2) Prestretching to eliminate permanent construction stretch and to obtain a verifiable modulus of elasticity.
(3) Color coding or other verifiable marking of each different size cable for field verification.
(4) The capacity of all components of the brace assemblies, including the field connections, to maintain the manufacturer's minimum certified break strength.
(5) Manufacturer's published design data sheets/manual showing product design guidelines, including connection details, load calculation procedures for sizing of braces, and the maximum recommended horizontal load-carrying capacity of the brace assemblies including the associated fasteners as described in Figure 9.3.5.9.1. The maximum allowable horizontal loads shall not exceed the manufacturer's minimum certified break strength of the brace assemblies, excluding fasteners, after taking a safety factor of 1.5 and then adjusting for the brace angle.
(6) Brace product shipments accompanied by the manufacturer's certification of the minimum break strength and prestretching and installation instructions.

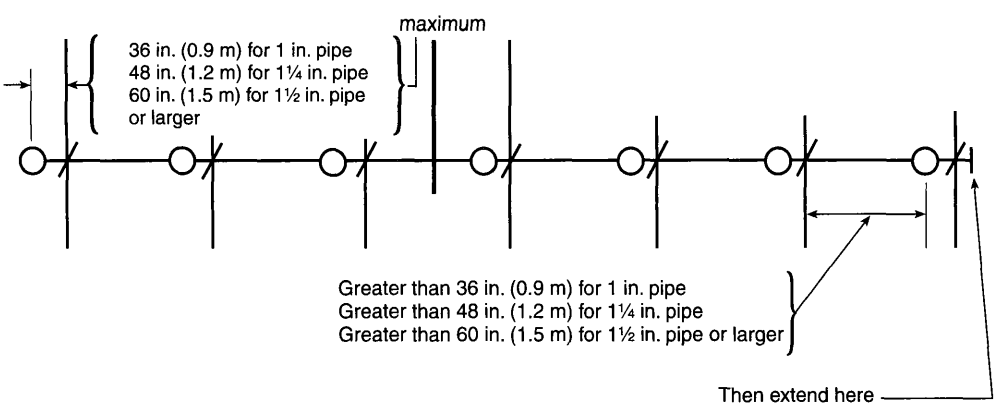


FIGURE A.9.2.3.4 Distance from Sprinkler to Hanger.

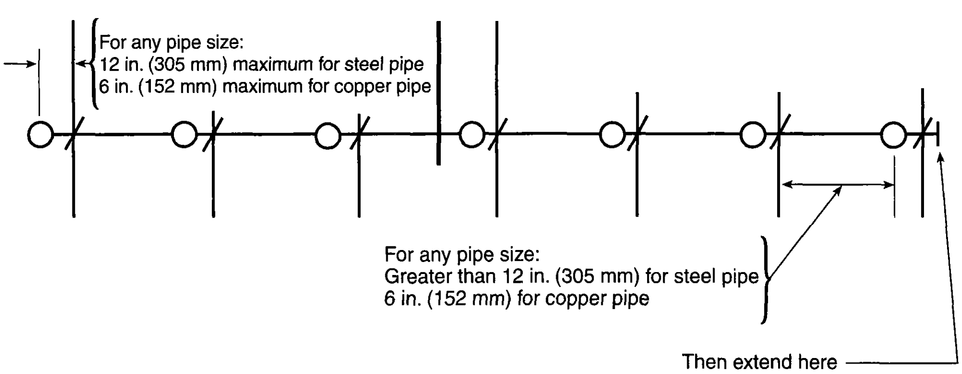
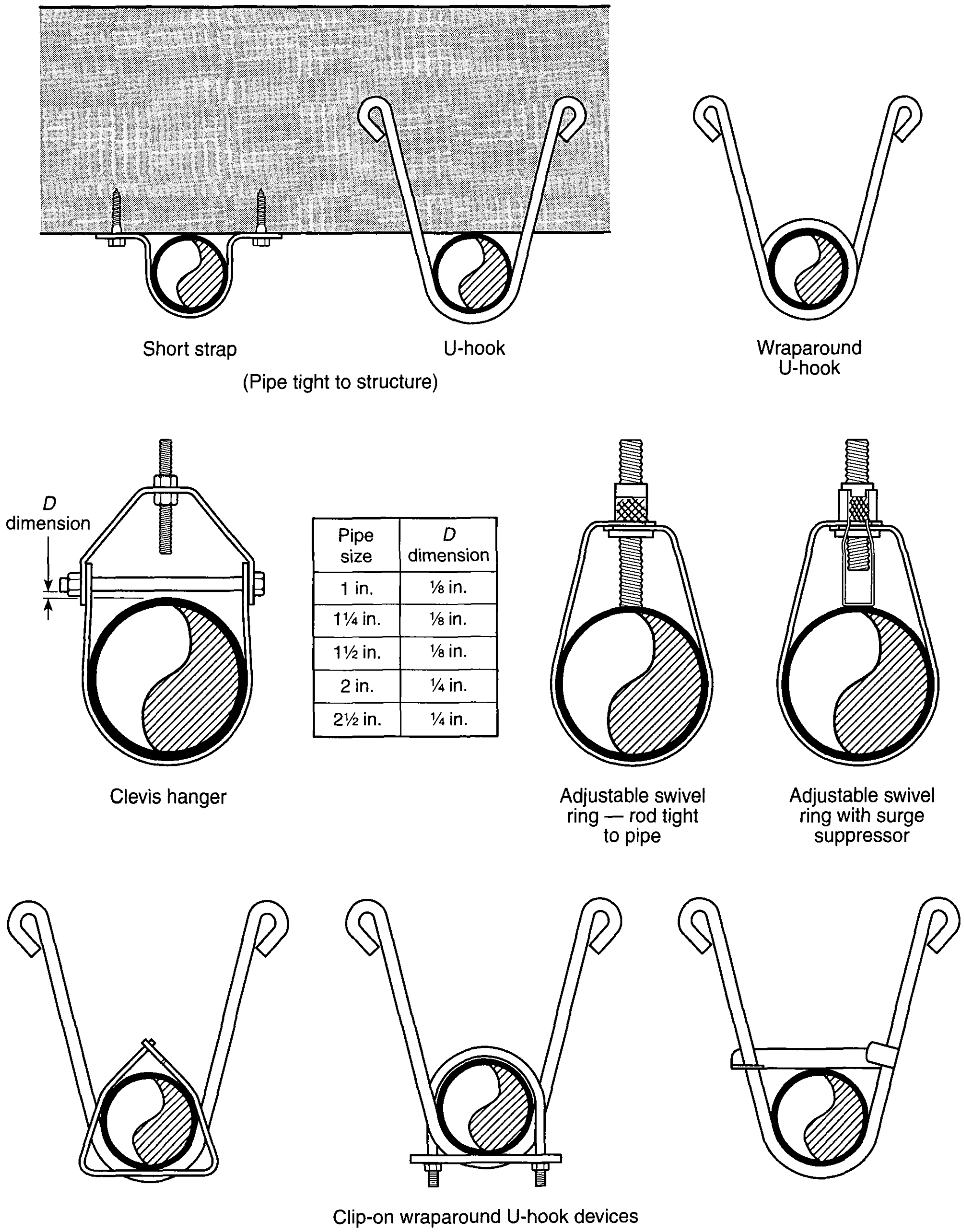


FIGURE A.9.2.3.4.3(a) Distance from Sprinkler to Hanger Where Maximum Pressure Exceeds 100 psi (6.9 bar) and a Branch Line Above a Ceiling Supplies Pendent Sprinklers Below the Ceiling.



Pipe size	D dimension
1 in.	⅛ in.
1¼ in.	⅛ in.
1½ in.	⅛ in.
2 in.	¼ in.
2½ in.	¼ in.

FIGURE A.9.2.3.4.3(b) Examples of Acceptable Hangers for End-of-Line (or Armover) Pendent Sprinklers.

(7) The manufacturer's literature, including any special tools or precautions required to ensure proper installation.
(8) A means to prevent vertical motion due to seismic forces when required.

Table A.9.3.5.2.2 identifies some specially listed tension-only bracing systems.

A.9.3.5.5.1 The four-way brace provided at the riser can also provide longitudinal and lateral bracing for adjacent mains.

Table A.9.3.5.2.2 Specially Listed Tension-Only Seismic Bracing

Materials and Dimensions	Standard
Manual for Structural Application of Steel Cables	ASCE 19-96
Wire Rope Users Manual of the Wire Rope Technical Board	ASCE 19-96
Mechanical Strength Requirements	ASTM A 603
Breaking Strength Failure Testing	ASTM E 8

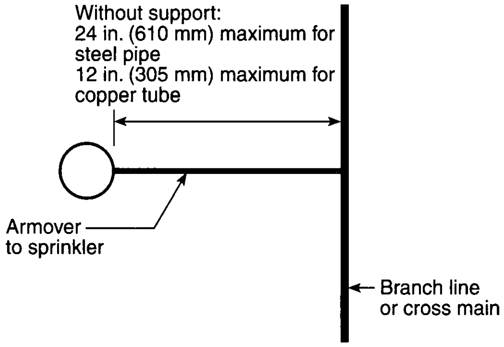
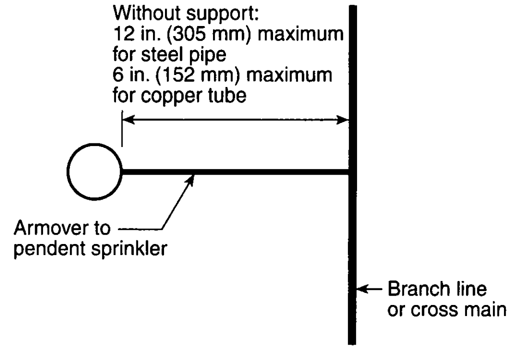


FIGURE A.9.2.3.5 Maximum Length for Unsupported Armover.



Note: The pendent sprinkler can be installed either directly in the fitting at the end of the armover or in a fitting at the bottom of a drop nipple.

FIGURE A.9.2.3.5.2 Maximum Length of Unsupported Armover Where the Maximum Pressure Exceeds 100 psi (6.9 bar) and a Branch Line Above a Ceiling Supplies Pendent Sprinklers Below the Ceiling.

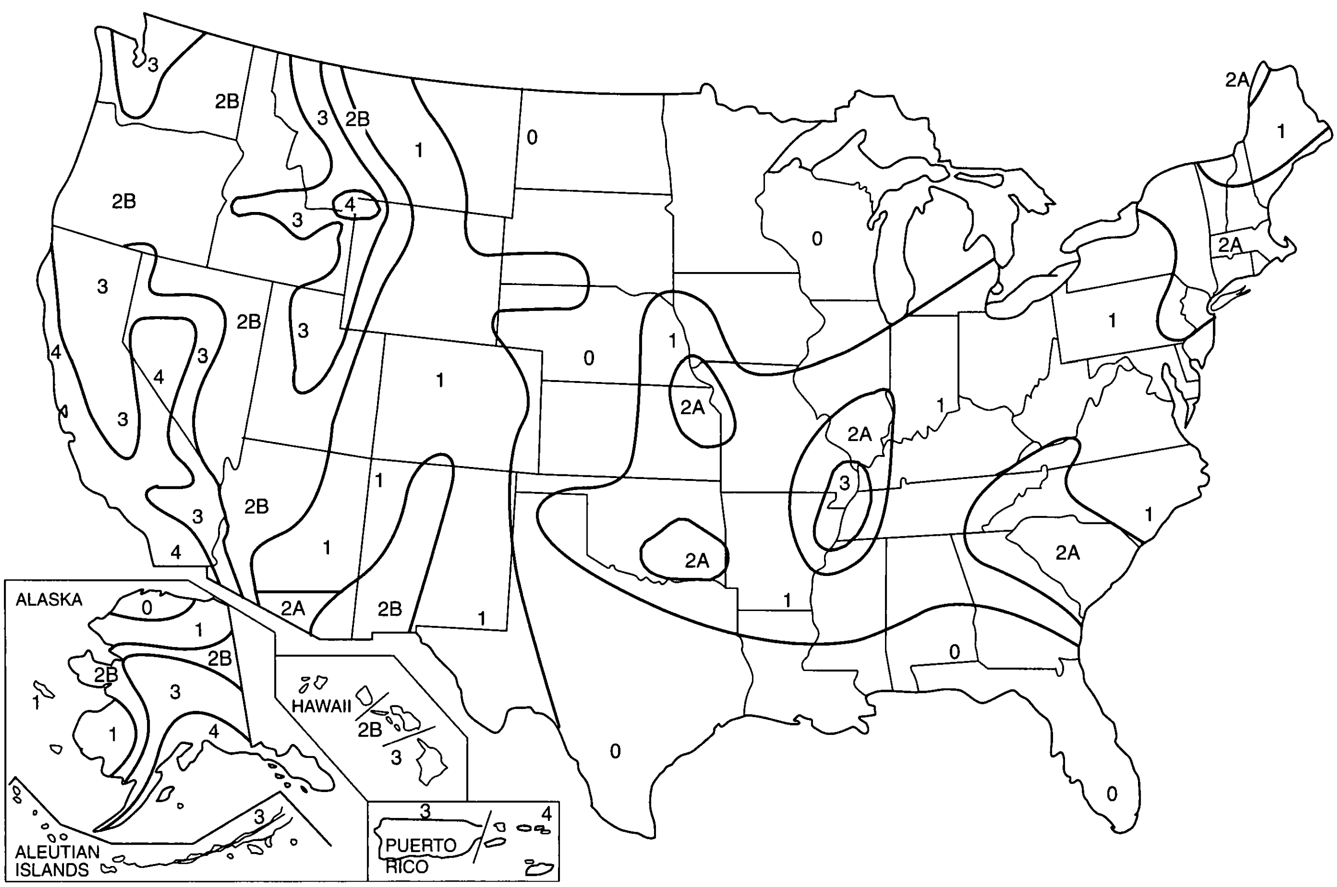


FIGURE A.9.3.1(a) Seismic Zone Map of the United States.

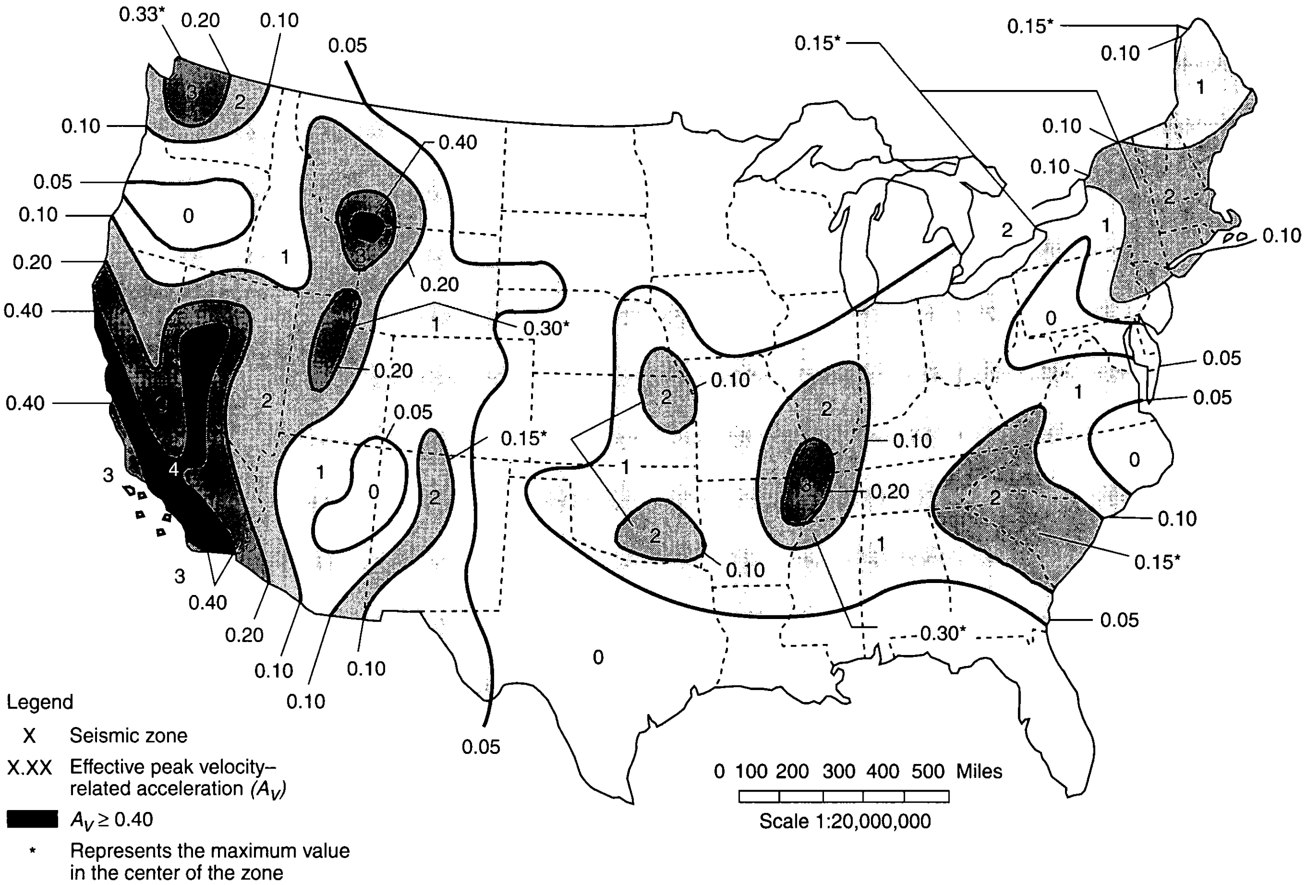
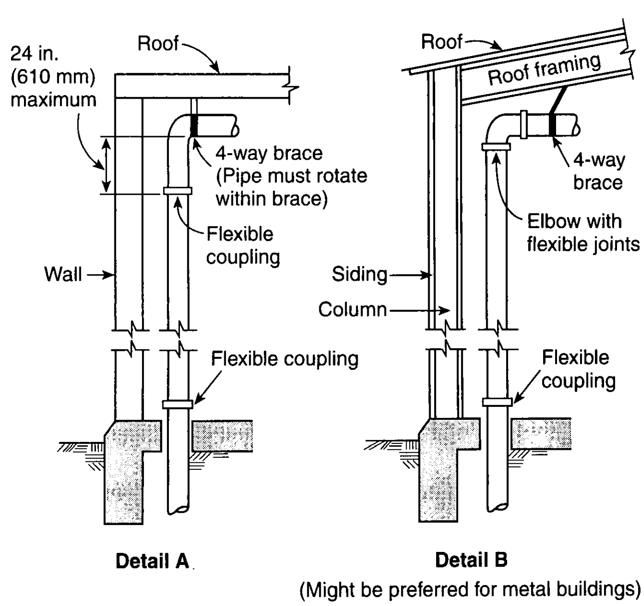


FIGURE A.9.3.1(b) Map of Seismic Zones and Effective Peak Velocity-Related Acceleration (A_v) for the Contiguous 48 States; Linear Interpolation Between Contours is Acceptable.



Note to Detail A: The four-way brace should be attached above the upper flexible coupling required for the riser and preferably to the roof structure if suitable. The brace should not be attached directly to a plywood or metal deck.

FIGURE A.9.3.2(a) Riser Details.

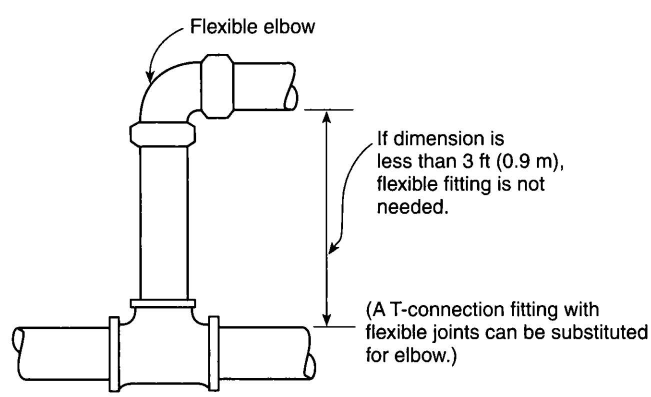


FIGURE A.9.3.2(b) Detail at Short Riser.

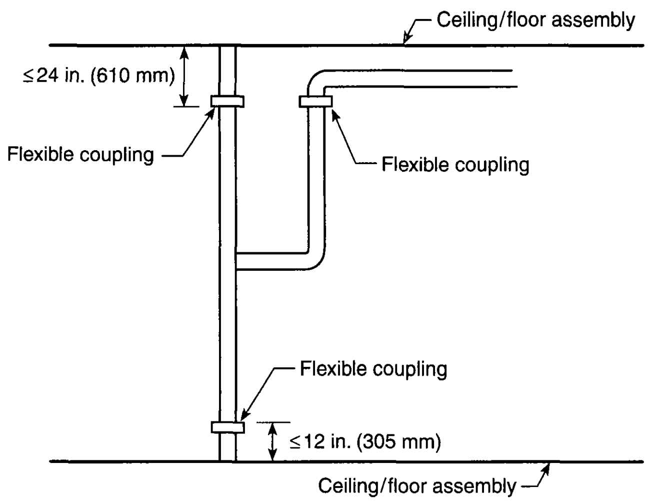


FIGURE A.9.3.2.3(2) Flexible Coupling on Main Riser and Branch Line Riser.

A.9.3.5.6 *Location of Sway Bracing.* Two-way braces are either longitudinal or lateral depending on their orientation with the axis of the piping. *[See Figure A.9.3.5.6(a), Figure A.9.3.5.6(b), Figure A.9.3.5.6(c), and Figure A.9.3.5.6(d).]* The simplest form of two-way brace is a piece of steel pipe or angle. Because the brace must act in both compression and tension, it is necessary to size the brace to prevent buckling.

An important aspect of sway bracing is its location. In Building 1 of Figure A.9.3.5.6(a), the relatively heavy main will pull on the branch lines when shaking occurs. If the branch lines are held rigidly to the roof or floor above, the fittings can fracture due to the induced stresses.

Bracing should be on the main as indicated at Location B. With shaking in the direction of the arrows, the light branch lines will be held at the fittings. Where necessary, a lateral brace or other restraint should be installed to prevent a branch line from striking against building components or equipment.

A four-way brace is indicated at Location A. This keeps the riser and main lined up and also prevents the main from shifting.

In Building 1, the branch lines are flexible in a direction parallel to the main, regardless of building movement. The heavy main cannot shift under the roof or floor, and it also steadies the branch lines. While the main is braced, the flexible couplings on the riser allow the sprinkler system to move with the floor or roof above, relative to the floor below.

Figure A.9.3.5.6(b), Figure A.9.3.5.6(c), and Figure A.9.3.5.6(d) show typical locations of sway bracing.

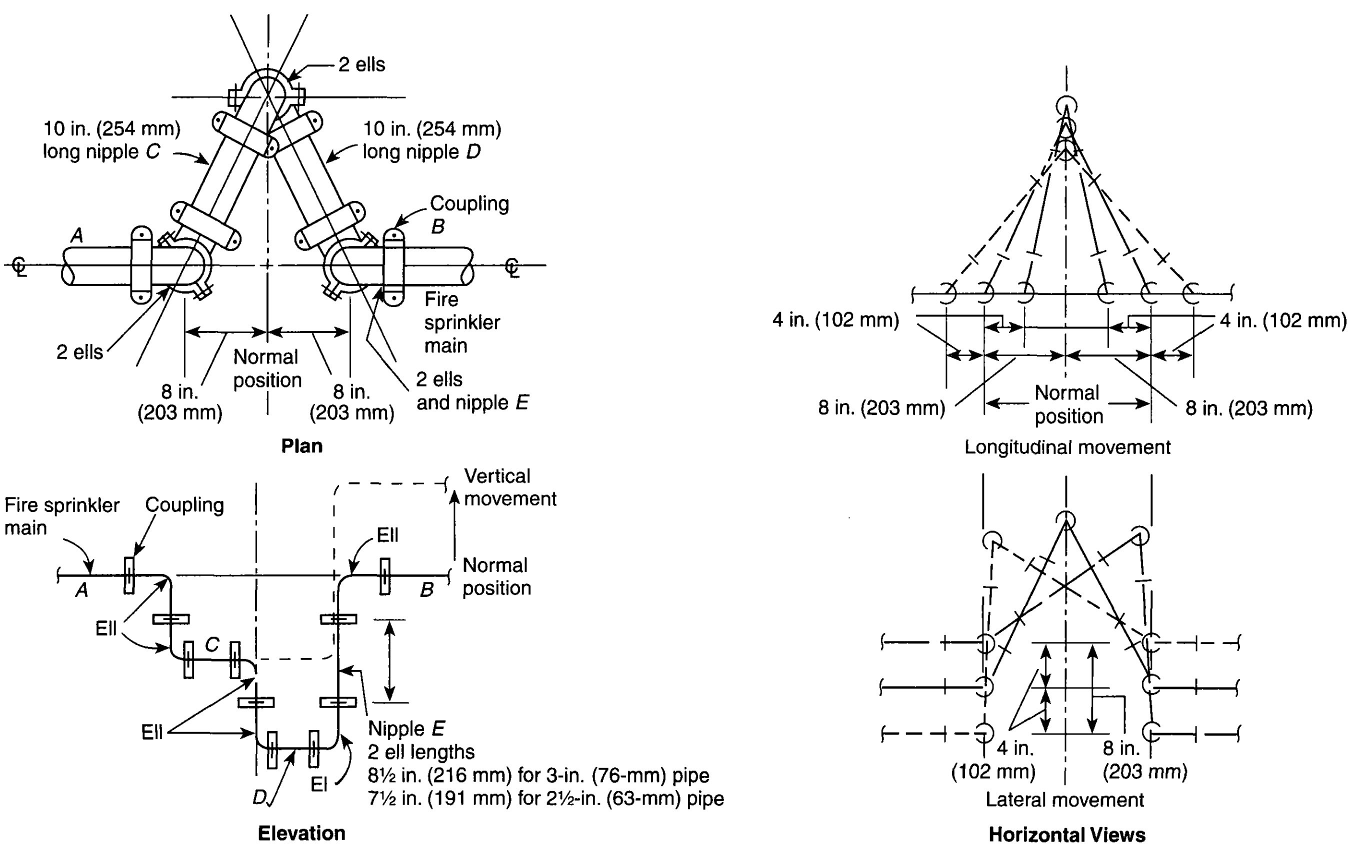


FIGURE A.9.3.3 Seismic Separation Assembly. Shown are an 8-in. (203-mm) Separation Crossed by Pipes up to 4 in. (102 mm) in Nominal Diameter. For Other Separation Distances and Pipe Sizes, Lengths and Distances Should Be Modified Proportionally.

Seismic Bracing Calculations

Sheet ______ of ______

Project: ______________________

Address: ______________________

____

Contractor: ______________________

Address: ______________________

____

Telephone: ______________________

Fax: ______________________

Brace Information

Length of brace: ____________

Diameter of brace: ____________

Type of brace: ____________

Angle of brace: ____________

Least radius of gyration:* ____________

L/R value:* ____________

Maximum horizontal load: ____________

Fastener Information

Orientation of connecting surface: ____________

Fastener:

Type: ____________

Diameter: ____________

Length (in wood): ____________

Maximum load: ____________

Seismic Brace Attachments

Structure attachment fitting or tension-only bracing system:

Make: ____________ Model: ____________

Listed load rating: ______ Adjusted load rating per 9.3.5.10.3: ______

Sway brace (pipe attachment) fitting:

Make: ____________ Model: ____________

Listed load rating: ______ Adjusted load rating per 9.3.5.10.3: ______

Seismic Brace Assembly Detail

(Provide detail on plans)

Brace identification no.
(to be used on plans) ____________

☐ Lateral brace ☐ Longitudinal brace

Sprinkler System Load Calculation [F_p = ____ W_p (default is 0.5)]

Diameter	Type	Length (ft)	Total (ft)	Weight per ft	Total Weight
				lb/ft	lb
				lb/ft	lb
				lb/ft	lb
				lb/ft	lb
				lb/ft	lb
				Total weight	lb
				$F_p \times 1.15$	lb

* *Excludes tension-only bracing systems*

FIGURE A.9.3.5(a) Seismic Bracing Calculation Form.

Seismic Bracing Calculations

Sheet ________ of ________

Project:	Acme Warehouse	Contractor:	Smith Sprinkler Company
Address:	321 First Street	Address:	123 Main Street
	Any City, Any State		Any City, Any State
		Telephone:	(555) 555-1234
		Fax:	(555) 555-4321

Brace Information

Length of brace:	6 ft 8 in.
Diameter of brace:	1 in.
Type of brace:	Schedule 40
Angle of brace:	30° to 45°
Least radius of gyration:*	0.42
L/R value:*	200
Maximum horizontal load:	1767 lb

Fastener Information

Orientation of connecting surface: "D"

Fastener:

Type:	Through bolt
Diameter:	5/8 in.
Length (in wood):	3 5/8 in.
Maximum load:	491 lb

Seismic Brace Attachments

Structure attachment fitting or tension-only bracing system:

Make: Acme Model: 123

Listed load rating: 1000 Adjusted load rating per 9.3.5.10.3: 500

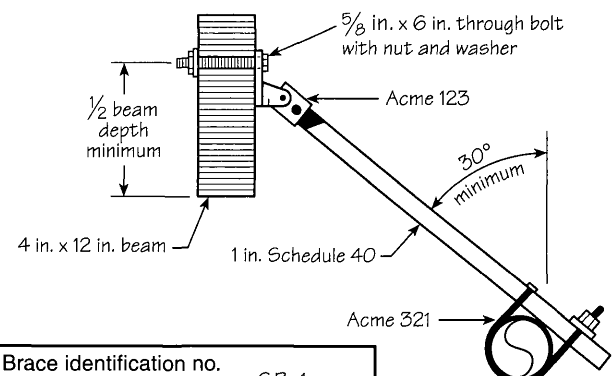
Sway brace (pipe attachment) fitting:

Make: Acme Model: 321

Listed load rating: 1200 Adjusted load rating per 9.3.5.10.3: 600

Seismic Brace Assembly Detail

(Provide detail on plans)



Brace identification no. (to be used on plans) SB-1

☒ Lateral brace ☐ Longitudinal brace

Sprinkler System Load Calculation [F_p =____W_p (default is 0.5)]

Diameter	Type	Length (ft)	Total (ft)	Weight per ft	W_p	Total Weight
1 in.	Sch 40	15 ft + 25 ft + 8 ft + 22 ft	70 ft	2.05 lb/ft	0.5	71.74 lb
1¼ in.	Sch 40	25 ft + 33 ft + 18 ft	76 ft	2.93 lb/ft	0.5	111.34 lb
1½ in.	Sch 40	8 ft + 8 ft + 10 ft + 10 ft	36 ft	3.61 lb/ft	0.5	64.98 lb
2 in.	Sch 40	20 ft	20 ft	5.13 lb/ft	0.5	51.3 lb
4 in.	Sch 10	20 ft	20 ft	11.78 lb/ft	0.5	119.5 lb
				Total weight		416.87 lb
				F_p × 1.15		480 lb

* Excludes tension-only bracing systems

FIGURE A.9.3.5(b) Sample Seismic Bracing Calculation.

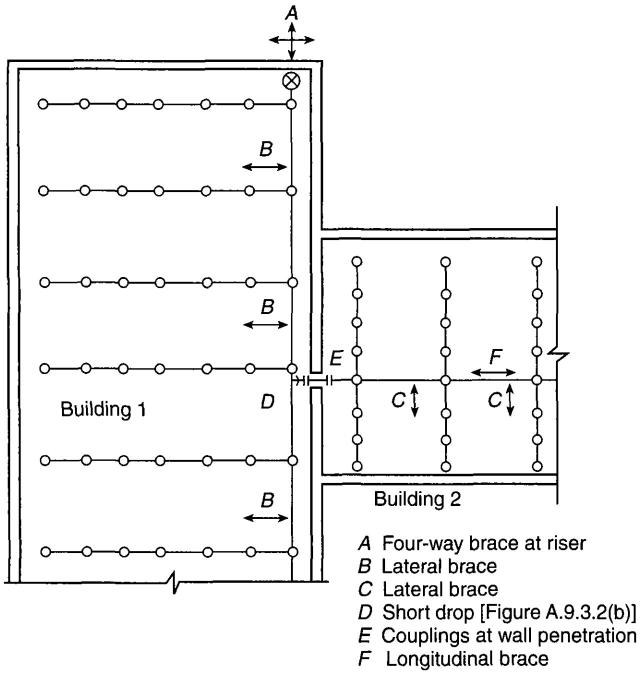


FIGURE A.9.3.5.6(a) Earthquake Protection for Sprinkler Piping.

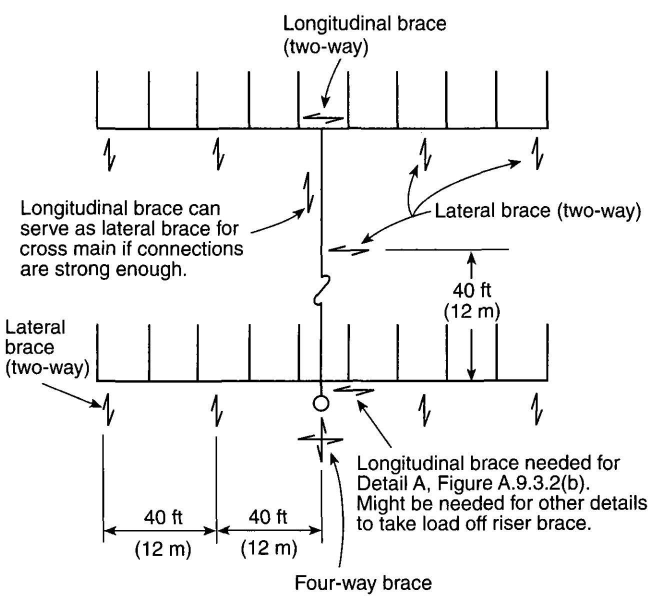


FIGURE A.9.3.5.6(b) Typical Location of Bracing on a Tree System.

For all threaded connections, sight holes or other means should be provided to permit indication that sufficient thread is engaged.

To properly size and space braces, it is necessary to employ the following steps:

(1) Based on the distance of mains from the structural members that will support the braces, choose brace shapes and sizes from Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c) such that the maximum slenderness ratios, l/r, do not exceed 300. The angle of the braces from the vertical should be at least 30 degrees and preferably 45 degrees or more.

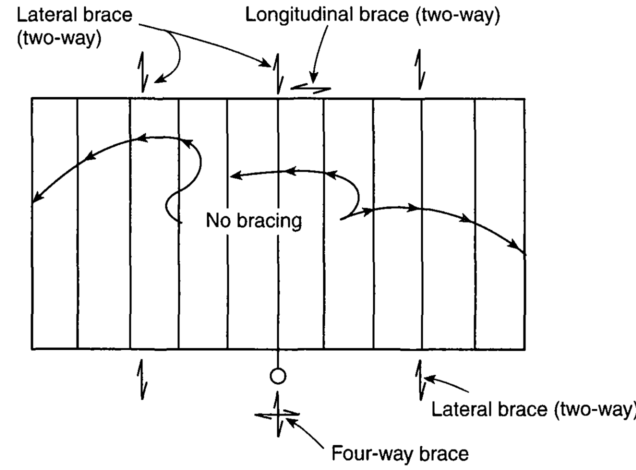


FIGURE A.9.3.5.6(c) Typical Location of Bracing on a Gridded System.

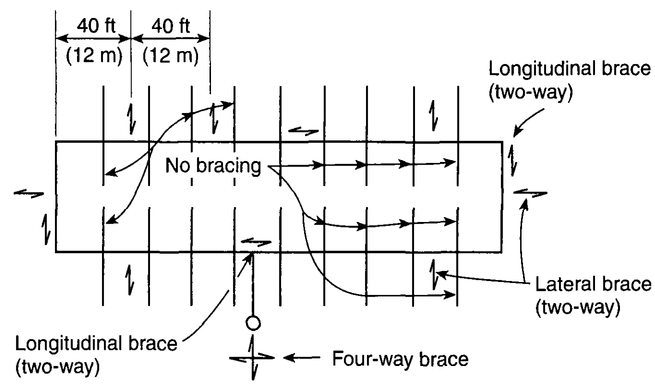


FIGURE A.9.3.5.6(d) Typical Location of Bracing on a Looped System.

(2) Tentatively space lateral braces at 40-ft (12-m) maximum distances along mains and tentatively space longitudinal braces at 80-ft (24-m) maximum distances along mains. Lateral braces should meet the piping at right angles, and longitudinal braces should be aligned with the piping.

(3) Determine the total load tentatively applied to each brace in accordance with the examples shown in Figure A.9.3.5.6(e) and the following:

(a) For the loads on lateral braces on cross mains, add one-half the weight of the branch to one-half the weight of the portion of the cross main within the zone of influence of the brace. *[See examples 1, 3, 6, and 7 in Figure A.9.3.5.6(e).]*

(b) For the loads on longitudinal braces on cross mains, consider only one-half the weight of the cross mains and feed mains within the zone of influence. Branch lines need not be included. *[See examples 2, 4, 5, 7, and 8 in Figure A.9.3.5.6(e).]* For the four-way bracing at the top of the riser, half the weight of the riser should be assigned

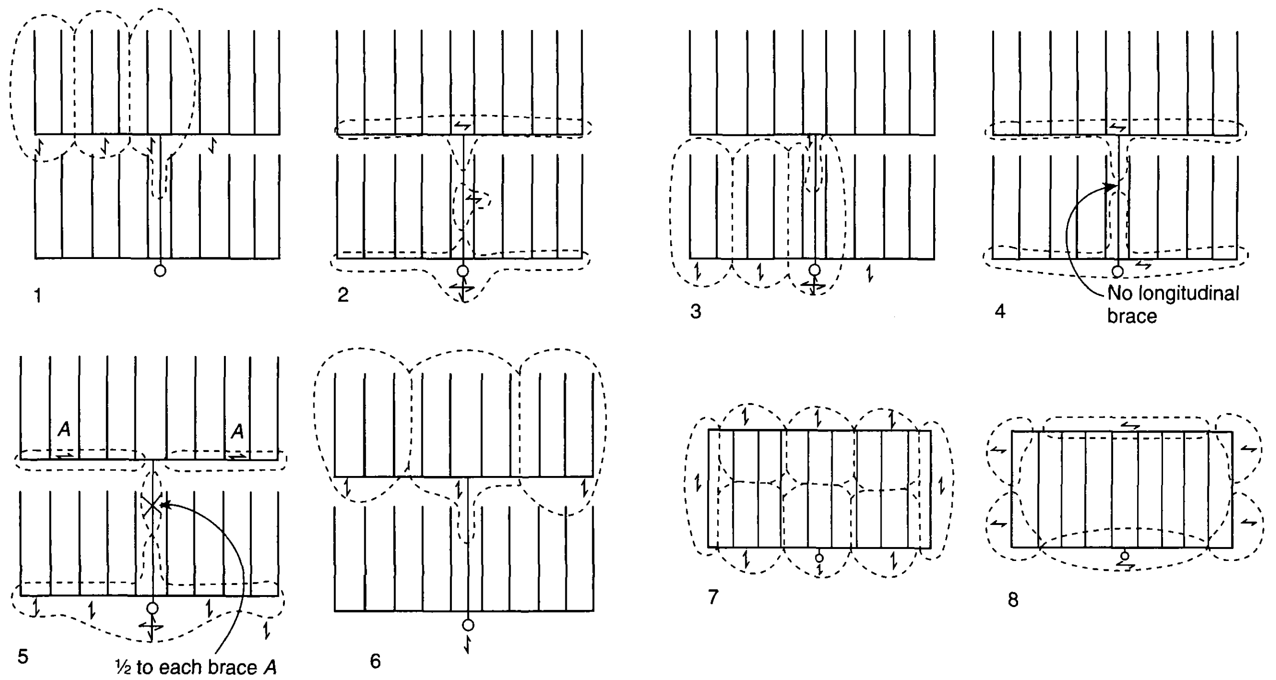


FIGURE A.9.3.5.6(e) Examples of Load Distribution to Bracing.

to both of the lateral and longitudinal loads as they are separately considered.

(c) For the four-way brace at the riser, add the longitudinal and lateral loads within the zone of influence of the brace *[see examples 2, 3, and 5 in Figure A.9.3.5.6(e)]*. For the four-way bracing at the top of the riser, half the weight of the riser should be assigned to both the lateral and longitudinal loads as they are separately considered.

(4) If the total expected loads are less than the maximums permitted in Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c) for the particular brace and orientation, go on to step (5). If not, add additional braces to reduce the zones of influence of overloaded braces.

(5) Check that fasteners connecting the braces to structural supporting members are adequate to support the expected loads on the braces in accordance with Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c). If not, again add additional braces or additional means of support.

Use the information on weights of water-filled piping contained within Table A.9.3.5.6. The factor of 1.15 is intended to approximate the additional weight of all the valves, fittings, and other devices attached to the system.

A.9.3.5.8 Sway brace members should be continuous. Where necessary, splices in sway bracing members should be designed and constructed to insure that brace integrity is maintained.

A.9.3.5.9 The criteria in Table 9.3.5.8.9(a), Table 9.3.5.8.9(b), and Table 9.3.5.8.9(c) are based upon the use of a shield-type expansion anchor. Use of other anchors in concrete should be in accordance with the listing provisions of the anchor.

Table A.9.3.5.6 Piping Weights for Determining Horizontal Load

	Weight of Water-Filled Pipe	
Nominal Dimensions	**lb/ft**	**kg/m**
Schedule 40 Pipe (in.)		
1	2.05	3.05
1¼	2.93	4.36
1½	3.61	5.37
2	5.13	7.63
2½	7.89	11.74
3	10.82	16.10
3½	13.48	20.06
4	16.40	24.41
5	23.47	34.93
6	31.69	47.16
8*	47.70	70.99
Schedule 10 Pipe (in.)		
1	1.81	2.69
1¼	2.52	3.75
1½	3.04	4.52
2	4.22	6.28
2½	5.89	8.77
3	7.94	11.82
3½	9.78	14.55
4	11.78	17.53
5	17.30	25.75
6	23.03	34.27
8	40.08	59.65

* Schedule 30.

Current fasteners for anchoring to concrete are referred to as expansion anchors. Expansion anchors come in two types. Deformation-controlled anchors are set by driving a plug into the expansion port in the anchor or driving the anchor over a plug that expands the end of the anchor into the concrete. Torque-controlled expansion anchors are set by applying a torque to the anchor, usually to a nut, which causes the expansion sleeves to be pressed against the wall of the drilled hole.

Consideration should be given with respect to the position near the edge of the concrete and to the type of bolts used in conjunction with the anchors.

A.9.3.6.1 Wires used for piping restraints should be attached to the branch line with two tight turns around the pipe and fastened with four tight turns within 1½ in. (38 mm), and should be attached to the structure in accordance with the details shown in Figure A.9.3.6.1(a) through Figure A.9.3.6.1(d) or other approved method.

A.9.3.6.4 The restraining wire should be provided as close as possible to the hanger.

A.9.3.6.5 Such restraint can be provided by using the restraining wire discussed in 9.3.6.1.

A.10.1 The term *underground* is intended to mean direct buried piping. For example, piping installed in trenches and tunnels but exposed should be treated as aboveground piping.

Loop systems for yard piping are recommended for increased reliability and improved hydraulics. Loop systems should be sectionalized by placing valves at branches and at strategic locations to minimize the extent of impairments.

A.10.1.1 Copper tubing (Type K) with brazed joints conforming to Table 10.1.1 and Table 10.2.1(a) is acceptable for underground service. Listing and labeling information, along with applicable publications for reference, follows:

(1) *Listing and Labeling.* Testing laboratories list or label the following:
   (a) Cast-iron and ductile iron pipe (cement-lined and unlined, coated and uncoated)
   (b) Asbestos-cement pipe and couplings
   (c) Steel pipe
   (d) Copper pipe
   (e) Fiberglass filament-wound epoxy pipe and couplings
   (f) Polyethylene pipe
   (g) Polyvinyl chloride (PVC) pipe and couplings
   (h) Underwriters Laboratories Inc. lists, under reexamination service, reinforced concrete pipe (cylinder pipe, nonprestressed and prestressed).

(2) *Pipe Standards.* The various types of pipe are usually manufactured to one of the following standards:
   (a) ASTM C296, *Standard Specification for Asbestos-Cement Pressure Pipe*
   (b) AWWA C151, *Ductile Iron Pipe, Centrifugally Cast for Water*
   (c) AWWA C300, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*
   (d) AWWA C301, *Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids*
   (e) AWWA C302, *Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids*
   (f) AWWA C303, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids*
   (g) AWWA C400, *Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water and Other Liquids*
   (h) AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water and Other Liquids*

A.10.1.4 The following pipe design manuals can be used as guides:

(1) AWWA C150, *Thickness Design of Ductile Iron Pipe*
(2) AWWA C401, *Standard Practice for the Selection of Asbestos-Cement Water Pipe*
(3) AWWA M41, *Ductile Iron Pipe and Fittings*
(4) *Concrete Pipe Handbook,* American Concrete Pipe Association

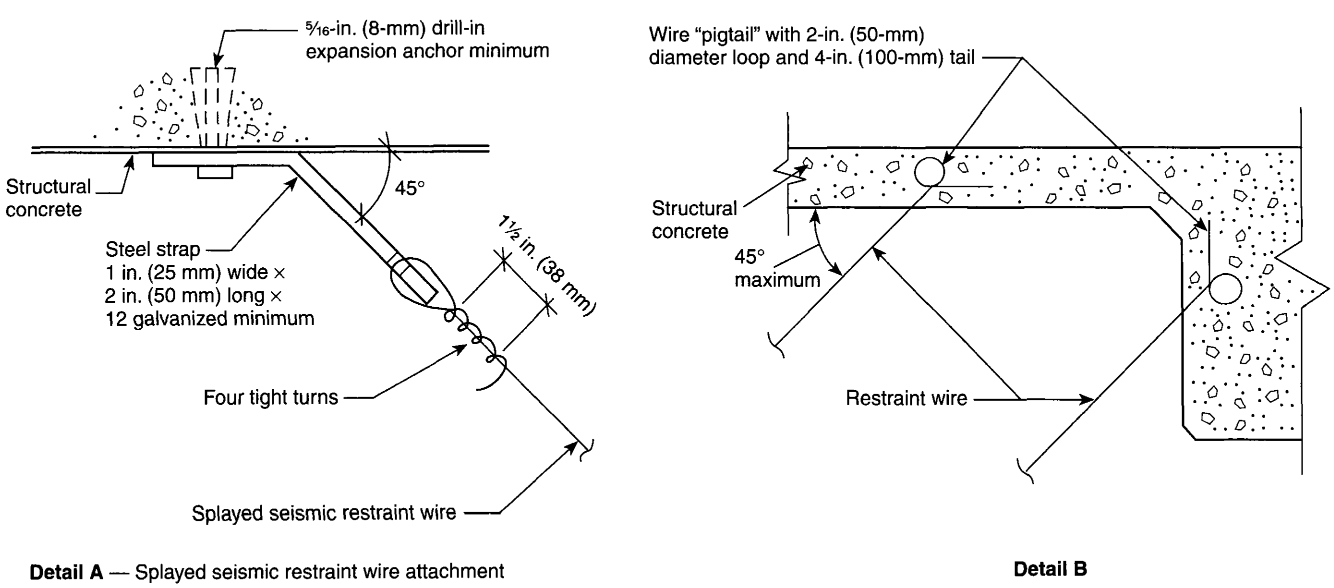


FIGURE A.9.3.6.1(a) Wire Attachment to Cast-in-Place Concrete.

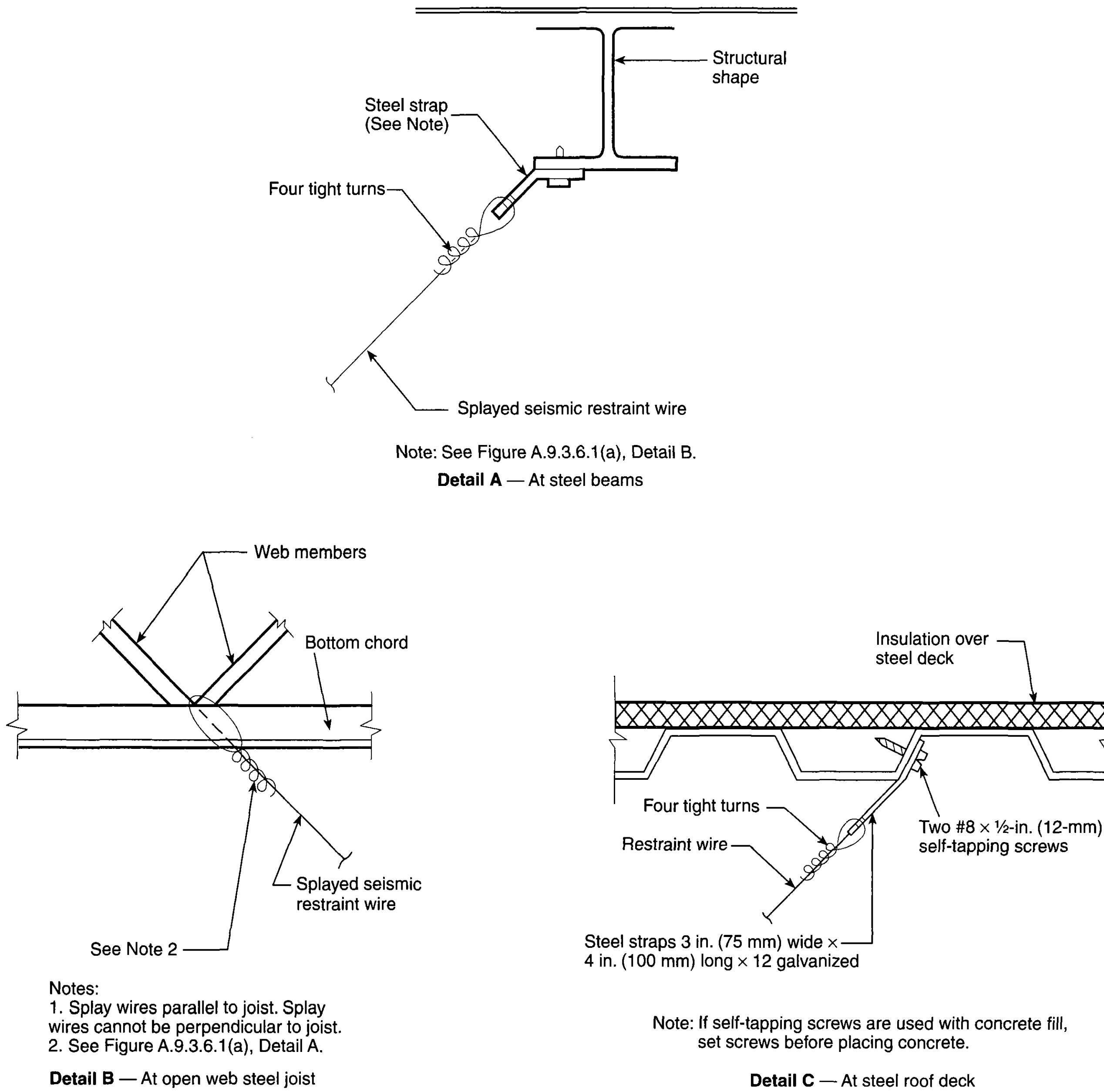


FIGURE A.9.3.6.1(b) Acceptable Details — Wire Connections to Steel Framing.

A.10.1.6 The following standards apply to the application of coating and linings:

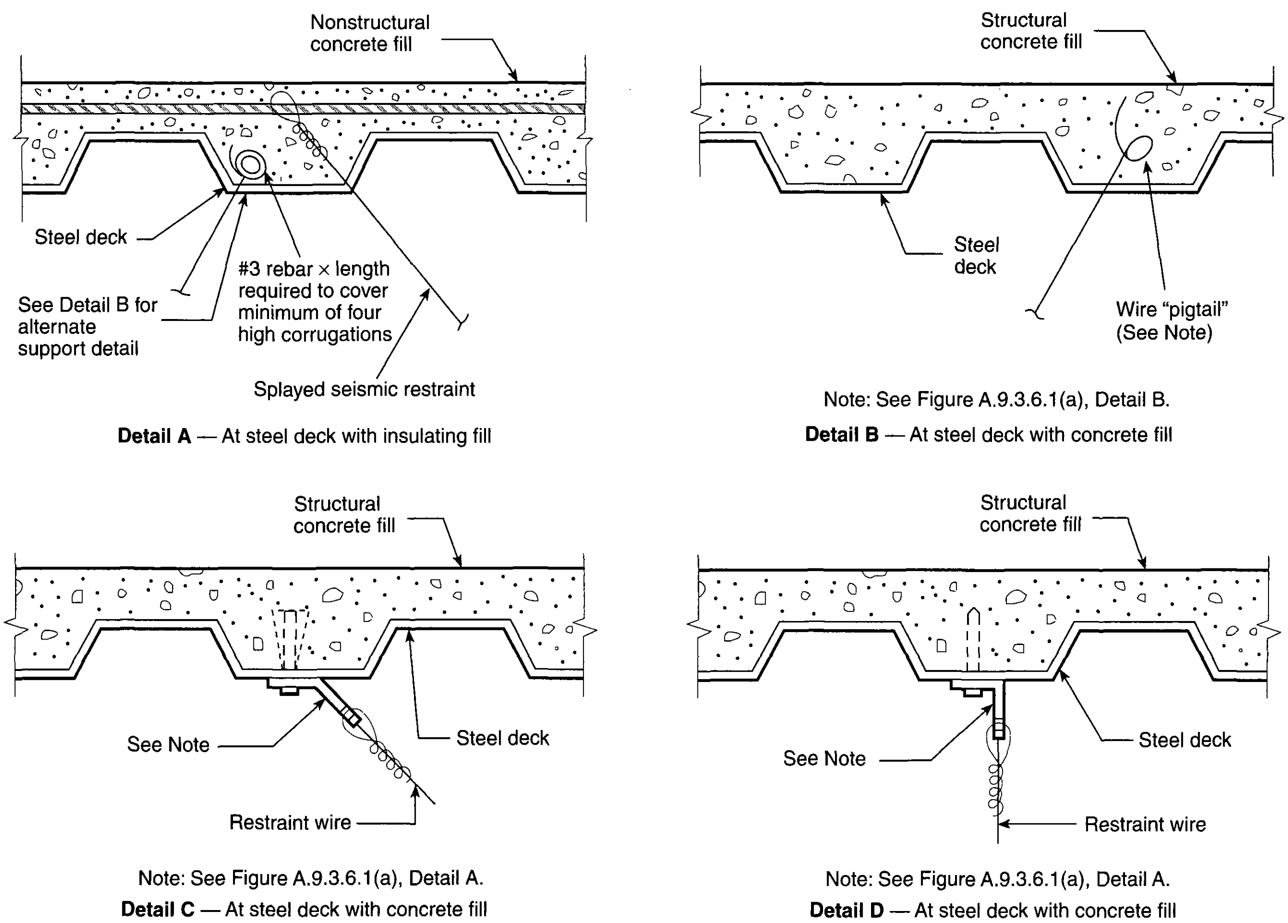
(1) AWWA C104, *Cement Mortar Lining For Ductile Iron Pipe and Fittings for Water*
(2) AWWA C105, *Polyethylene Encasement for Ductile Iron Pipe Systems*
(3) AWWA C203, *Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape — Hot Applied*
(4) AWWA C205, *Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 in. and Larger — Shop Applied*
(5) AWWA C602, *Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place*

A.10.2.4 The following standards apply to joints used with the various types of pipe:

(1) ASME B16.1, *Cast-Iron Pipe Flanges and Flanged Fittings*
(2) AWWA C111, *Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings*
(3) AWWA C115, *Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges*
(4) AWWA C206, *Field Welding of Steel Water Pipe*
(5) AWWA C606, *Grooved and Shouldered Joints*

A.10.2.5 Fittings generally used are cast iron with joints made to the specifications of the manufacturer of the particular type of pipe *(see the standards listed in A.10.2.4)*. Steel fittings also have some applications. The following standards apply to fittings:

(1) ASME B16.1, *Cast-Iron Pipe Flanges and Flanged Fittings*
(2) AWWA C110, *Ductile Iron and Gray Iron Fittings, 3-in. Through 48-in., for Water and Other Liquids*



Detail A — At steel deck with insulating fill

Detail B — At steel deck with concrete fill

Detail C — At steel deck with concrete fill

Detail D — At steel deck with concrete fill

For SI units, 1 in. = 25.4 mm.
Note: If self-tapping screws are used with concrete fill, set screws before placing concrete.

FIGURE A.9.3.6.1(c) Acceptable Details — Wire Connections to Steel Decking with Fill.

(3) AWWA C153, *Ductile Iron Compact Fittings, 3 in. through 24 in. and 54 in. through 64 in. for Water Service*
(4) AWWA C208, *Dimensions for Fabricated Steel Water Pipe Fittings*

A.10.4.1 The following documents apply to the installation of pipe and fittings:

(1) AWWA C603, *Standard for the Installation of Asbestos-Cement Water Pipe*
(2) AWWA C600, *Standard for the Installation of Ductile-Iron Water Mains and Their Appurtenances*
(3) AWWA M11, *A Guide for Steel Pipe Design and Installation*
(4) AWWA M41, *Ductile Iron Pipe and Fittings*
(5) *Concrete Pipe Handbook*, American Concrete Pipe Association
(6) *Handbook of PVC Pipe*, Uni-Bell Plastic Pipe Association
(7) *Installation Guide for Ductile Iron Pipe*, Ductile Iron Pipe Research Association
(8) *Thrust Restraint Design for Ductile Iron Pipe*, Ductile Iron Pipe Research Association

As there is normally no circulation of water in private fire mains, they require greater depth of covering than do public mains. Greater depth is required in a loose gravelly soil (or in rock) than in compact soil containing large quantities of clay. The recommended depth of cover above the top of underground yard mains is shown in Figure A.10.4.1.

A.10.5.1 In determining the need to protect aboveground piping from freezing, the lowest mean temperature should be considered as shown in Figure A.10.5.1.

A.10.6.7 Gray cast iron is not considered galvanically dissimilar to ductile iron. Rubber gasket joints (unrestrained push-on or mechanical joints) are not considered connected electrically. Metal thickness should not be considered a protection against corrosive environments. In the case of cast-iron or ductile iron pipe for soil evaluation and external protection systems, see Appendix A of AWWA C105, *Polyethylene Encasement for Ductile Iron Pipe Systems.*

A.10.8.1.1 It is a fundamental design principle of fluid mechanics that dynamic and static pressures, acting at changes in size or direction of a pipe, produce unbalanced thrust forces at locations such as bends, tees, wyes, dead ends, and reducer offsets. This design principle includes consideration of lateral soil pressure and pipe/soil friction, variables that can be reliably determined using current soil engineering knowledge. Refer to A.10.1.1 for a list of references for use in calculating and determining joint restraint systems.

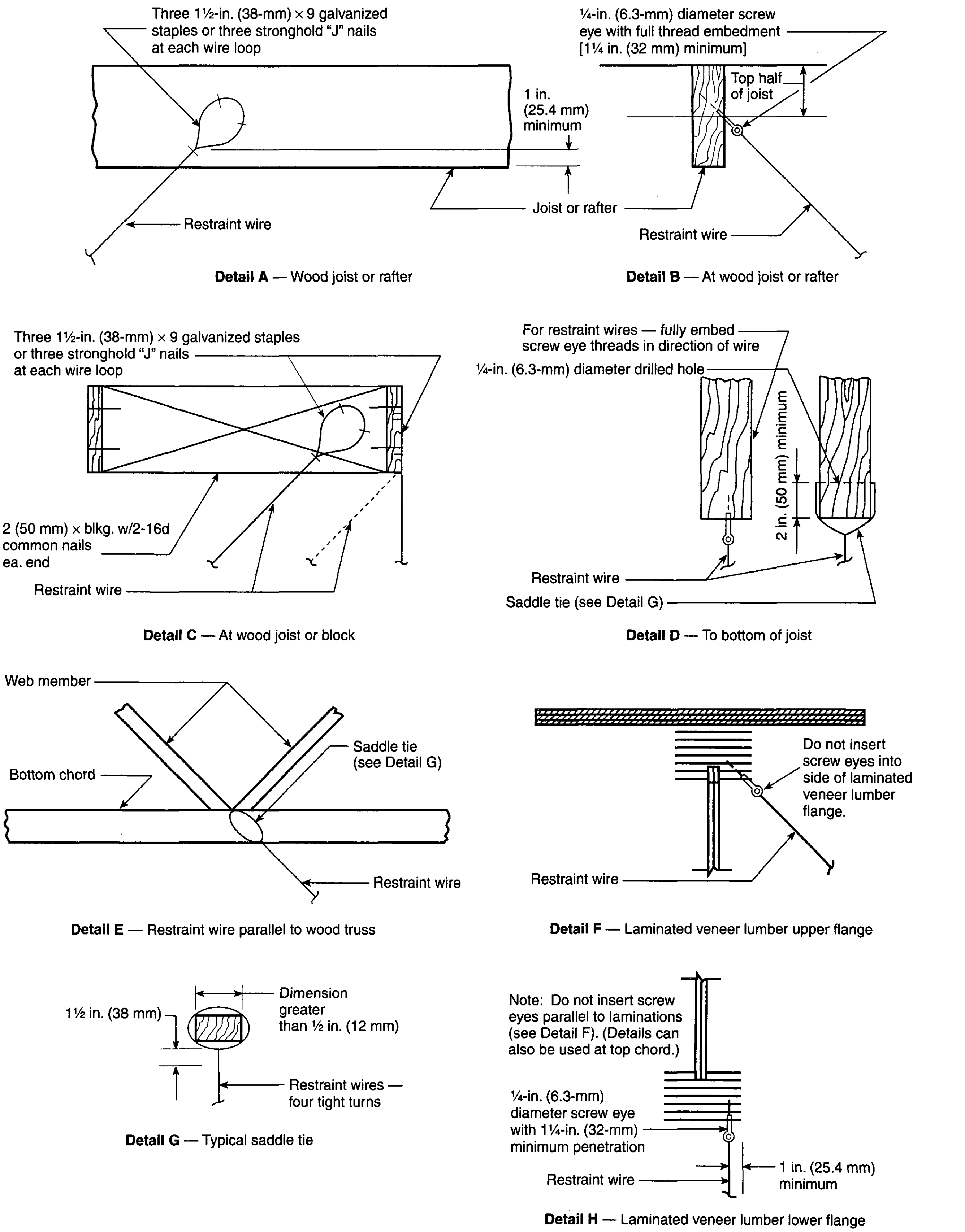


FIGURE A.9.3.6.1(d) Acceptable Details — Wire Connections to Wood Framing.

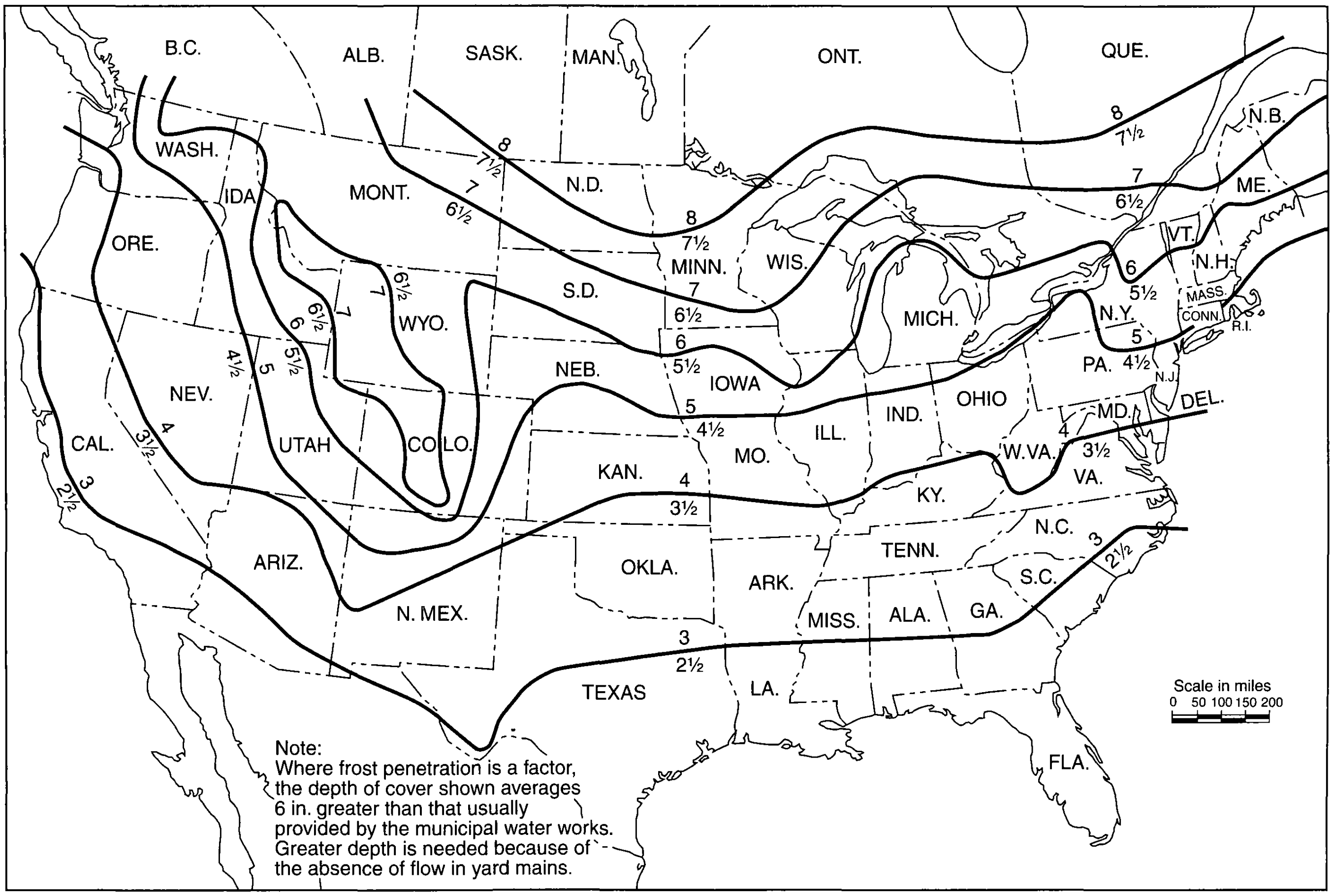


FIGURE A.10.4.1 Recommended Depth of Cover (in feet) Above Top of Underground Yard Mains.

Except for the case of welded joints and approved special restrained joints, such as is provided by approved mechanical joint retainer glands or locked mechanical and push-on joints, the usual joints for underground pipe are expected to be held in place by the soil in which the pipe is buried. Gasketed push-on and mechanical joints without special locking devices have limited ability to resist separation due to movement of the pipe.

A.10.8.2 Thrust Blocks. Concrete thrust blocks are one of the most common methods of restraint now in use, provided that stable soil conditions prevail and space requirements permit placement. Successful blocking is dependent upon factors such as location, availability and placement of concrete, and possibility of disturbance by future excavations.

Resistance is provided by transferring the thrust force to the soil through the larger bearing area of the block such that the resultant pressure against the soil does not exceed the horizontal bearing strength of the soil. The design of thrust blocks consists of determining the appropriate bearing area of the block for a particular set of conditions. The parameters involved in the design include pipe size, design pressure, angle of the bend (or configuration of the fitting involved), and the horizontal bearing strength of the soil.

Table A.10.8.2(a) gives the nominal thrust at fittings for various sizes of ductile iron and PVC piping. Figure A.10.8.2(a) shows an example of how thrust forces act on a piping bend. Figure A.10.8.2(b) shows an example of a typical connection to a fire protection systems riser.

Thrust blocks are generally categorized into two groups — bearing and gravity blocks. Figure A.10.8.2(c) depicts a typical bearing thrust block on a horizontal bend.

The following are general criteria for bearing block design:

(1) The bearing surface should, where possible, be placed against undisturbed soil.
(2) Where it is not possible to place the bearing surface against undisturbed soil, the fill between the bearing surface and undisturbed soil must be compacted to at least 90 percent Standard Proctor density.
(3) Block height *(h)* should be equal to or less than one-half the total depth to the bottom of the block (H_t) but not less than the pipe diameter *(D)*.
(4) Block height *(h)* should be chosen such that the calculated block width *(b)* varies between one and two times the height.

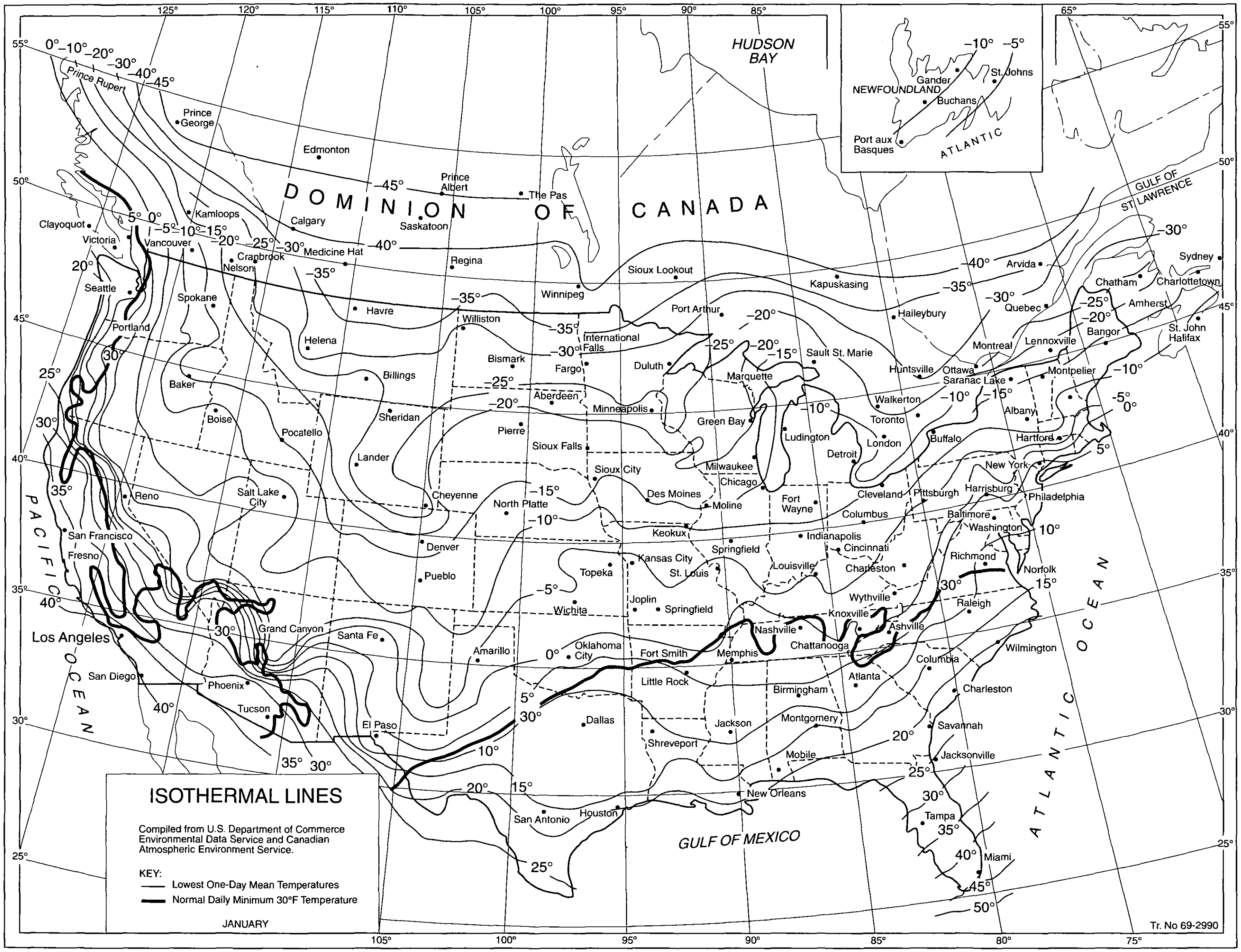
The required block area (A_b) is as follows:

$$A_b = (h)(b) = \frac{T(S_f)}{S_b}$$

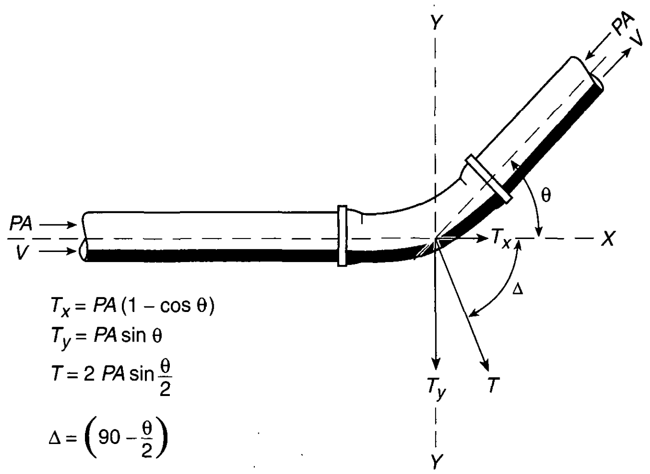
where:

A_b = required block area
h = block height
b = calculated block width
T = thrust force
S_f = safety factor
S_b = bearing strength

FIGURE A.10.5.1 Isothermal Lines — Lowest One-Day Mean Temperature (°F).



Compiled from United States Weather Bureau records.
SI units: °C = 5/9 (°F−32); 1 mi = 1.609 km.



- *T* Thrust force resulting from change in direction of flow
- T_x Component of the thrust force acting parallel to the original direction of flow
- T_y Component of the thrust force acting perpendicular to the original direction of flow
- *P* Water pressure
- *A* Cross-sectional area of the pipe interior
- *V* Velocity in direction of flow

FIGURE A.10.8.2(a) Thrust Forces Acting on a Bend.

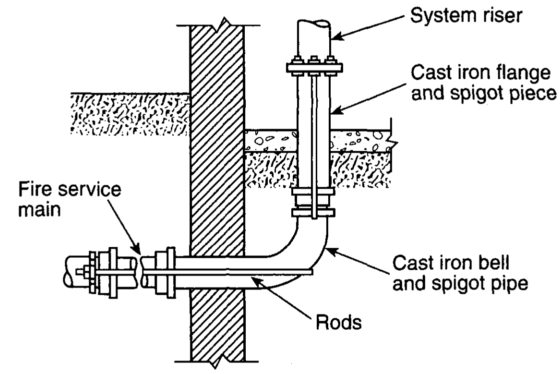
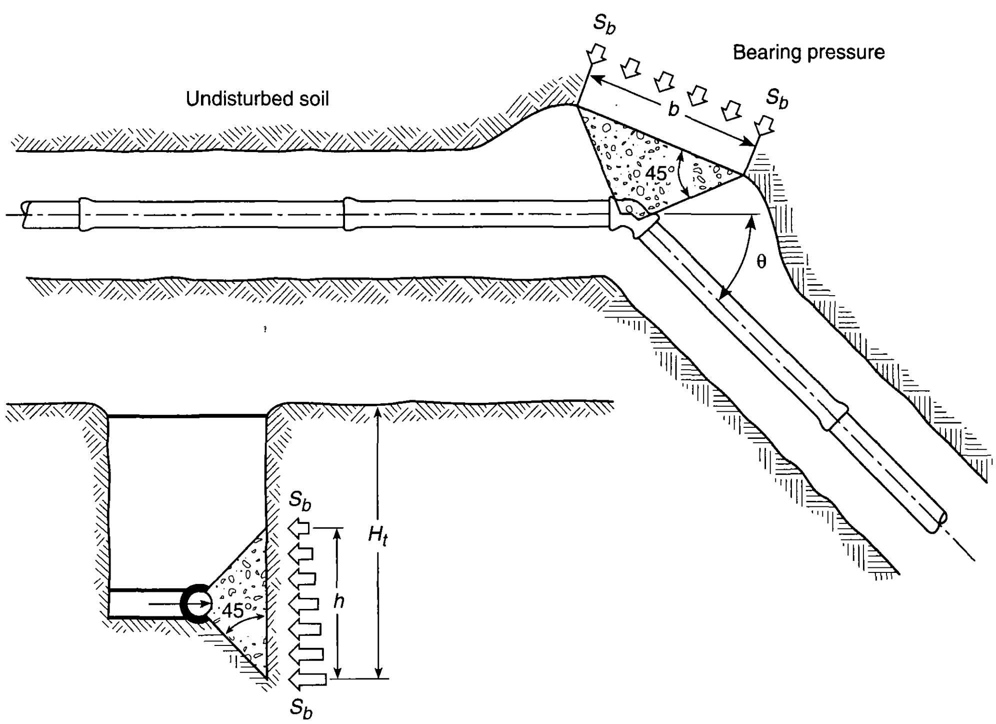
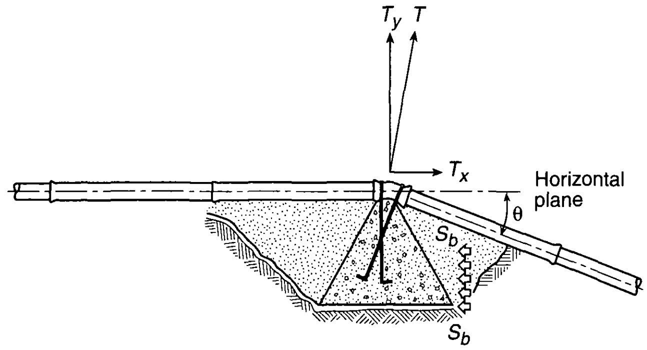


FIGURE A.10.8.2(b) Typical Connection to a Fire Protection System Riser.



- *T* Thrust force resulting from the change in direction of flow
- S_b Horizontal bearing strength of the soil

FIGURE A.10.8.2(c) Bearing Thrust Block.



T Thrust force resulting from the change of direction of flow
T_x Horizontal component of the thrust force
T_y Vertical component of the thrust force
S_b Horizontal bearing strength of the soil

FIGURE A.10.8.2(d) Gravity Thrust Block.

Table A.10.8.2(b) Horizontal Bearing Strengths

Soil	Bearing Strength, S_b lb/ft^2	Bearing Strength, S_b kN/m^2
Muck	0	0
Soft clay	1000	47.9
Silt	1500	71.8
Sandy silt	3000	143.6
Sand	4000	191.5
Sandy clay	6000	287.3
Hard clay	9000	430.9

Notes:
1. Although the bearing strength values in this table have been used successfully in the design of thrust blocks and are considered to be conservative, their accuracy is totally dependent on accurate soil identification and evaluation. The ultimate responsibility for selecting the proper bearing strength of a particular soil type must rest with the design engineer.
2. Gravity thrust blocks can be used to resist thrust at vertical down bends. In a gravity thrust block, the weight of the block is the force providing equilibrium with the thrust force. The design problem is then to calculate the required volume of the thrust block of a known density. The vertical component of the thrust force in Figure A.10.8.2(d) is balanced by the weight of the block.

Table A.10.8.2(a) Thrust at Fittings at 100 psi (6.9 bar) Water Pressure for Ductile Iron and PVC Pipe

Nominal Pipe Diameter (in.)	Total Pounds Dead End	90-Degree Bend	45-Degree Bend	22½-Degree Bend	11¼-Degree Bend	5⅝-Degree Bend
4	1,810	2,559	1,385	706	355	162
6	3,739	5,288	2,862	1,459	733	334
8	6,433	9,097	4,923	2,510	1,261	575
10	9,677	13,685	7,406	3,776	1,897	865
12	13,685	19,353	10,474	5,340	2,683	1,224
14	18,385	26,001	14,072	7,174	3,604	1,644
16	23,779	33,628	18,199	9,278	4,661	2,126
18	29,865	42,235	22,858	11,653	5,855	2,670
20	36,644	51,822	28,046	14,298	7,183	3,277
24	52,279	73,934	40,013	20,398	10,249	4,675
30	80,425	113,738	61,554	31,380	15,766	7,191
36	115,209	162,931	88,177	44,952	22,585	10,302
42	155,528	219,950	119,036	60,684	30,489	13,907
48	202,683	286,637	155,127	79,083	39,733	18,124

Notes:
1. For SI units, 1 lb. = 0.454 kg.
2. To determine thrust at pressure other than 100 psi (6.9 bar), multiply the thrust obtained in the table by the ratio of the pressure to 100 psi (6.9 bar). For example, the thrust on a 12-in., 90-degree bend at 125 psi (8.6 bar) is 19,353 × 125/100 = 24,191 lb.

Then, for a horizontal bend, the following formula is used:

$$b = \frac{2(S_f)(P)(A)\sin(\theta/2)}{(h)(S_b)}$$

where:
S_f = safety factor (usually 1.5 for thrust block design)
P = water pressure
A = cross sectional area of the pipe interior
h = block height
S_b = horizontal bearing strength of the soil

A similar approach can be used to design bearing blocks to resist the thrust forces at locations such as tees and dead ends. Typical values for conservative horizontal bearing strengths of various soil types are listed in Table A.10.8.2(b).

In lieu of the values for soil bearing strength shown in Table A.10.8.2(b), a designer might choose to use calculated Rankine passive pressure (P_p) or other determination of soil bearing strength based on actual soil properties.

It can be easily be shown that $T_y = PA$ sin. The required volume of the block is as follows:

$$V_g = \frac{S_f PA\sin\theta}{W_m}$$

where:
S_f = safety factor
P = water pressure
A = cross sectional area of the pipe interior
W_m = density of the block material

In a case such as the one shown, the horizontal component of thrust force is calculated as follows:

$$T_x = PA(1-\cos\theta)$$

where:
P = water pressure
A = cross sectional area of the pipe interior

The horizontal component of thrust force must be resisted by the bearing of the right side of the block against the soil. Analysis of this aspect will follow the same principles as the previous section on bearing blocks.

A.10.8.3.5 Examples of materials and the standards covering these materials are as follows:

(1) Clamps, steel *(see Note)*
(2) Rods, steel *(see Note)*
(3) Bolts, steel (ASTM A 307, *Standard Specification for Carbon Steel Bolts and Studs*)
(4) Washers, steel *(see Note);* cast iron (Class A cast iron as defined by ASTM A 126, *Standard Specification for Gray Iron Casting for Valves, Flanges and Pipe Fittings*)
(5) Anchor straps and plug straps, steel *(see Note)*
(6) Rod couplings or turnbuckles, malleable iron (ASTM A 197, *Standard Specification for Cupola Malleable Iron*)

Steel of modified range merchant quality as defined in U.S. Federal Standard No. 66C, *Standard for Steel Chemical Composition and Harden Ability*, April 18, 1967, change notice No. 2, April 16, 1970, as promulgated by the U.S. Federal Government General Services Administration.

The materials specified in A.10.8.3.5(1) through (6) do not preclude the use of other materials that will also satisfy the requirements of this section.

A.10.10.2.1 Underground mains and lead-in connections to system risers should be flushed through hydrants at dead ends of the system or through accessible aboveground flushing outlets allowing the water to run until clear. Figure A.10.10.2.1 shows acceptable examples of flushing the system. If water is supplied from more than one source or from a looped system, divisional valves should be closed to produce a high-velocity flow through each single line. The flows specified in Table 10.10.2.1.3 will produce a velocity of at least 10 ft/sec (3 m/sec), which is necessary for cleaning the pipe and for lifting foreign material to an aboveground flushing outlet.

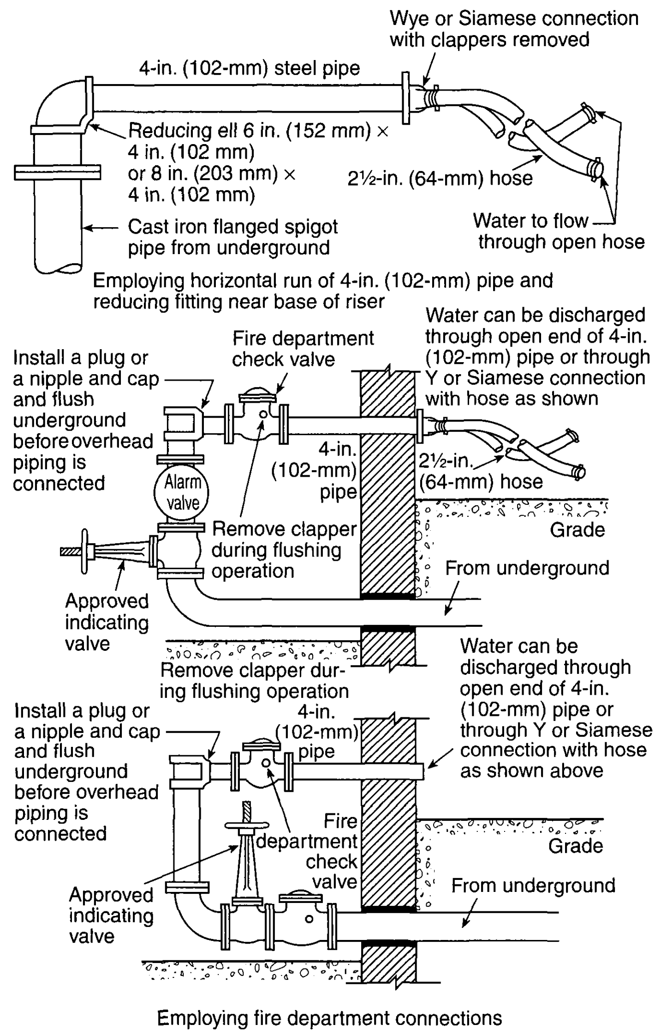


FIGURE A.10.10.2.1 Methods of Flushing Water Supply Connections.

A.10.10.2.2.1 A sprinkler system has for its water supply a connection to a public water service main. A 100-psi (6.9-bar) rated pump is installed in the connection. With a maximum normal public water supply of 70 psi (4.8 bar) at the low elevation point of the individual system or portion of the system being tested and a 120-psi (8.3-bar) pump (churn) pressure, the hydrostatic test pressure is 70 psi + 120 psi + 50 psi or 240 psi (16.5 bar).

To reduce the possibility of serious water damage in case of a break, pressure can be maintained by a small pump, the main controlling gate meanwhile being kept shut during the test.

Polybutylene pipe will undergo expansion during initial pressurization. In this case, a reduction in gauge pressure might not necessarily indicate a leak. The pressure reduction should not exceed the manufacturer's specifications and listing criteria.

When systems having rigid thermoplastic piping such as CPVC are pressure tested, the sprinkler system should be filled with water. The air should be bled from the highest and farthest sprinklers. Compressed air or compressed gas should never be used to test systems with rigid thermoplastic pipe.

A recommended test procedure is as follows: The water pressure is to be increased in 50-psi (3.4-bar) increments until the test pressure described in 10.10.2.2.1 is attained. After each increase in pressure, observations are to be made of the stability of the joints. These observations are to include such items as protrusion or extrusion of the gasket, leakage, or other factors likely to affect the continued use of a pipe in service. During the test, the pressure is not to be increased by the next increment until the joint has become stable. This applies particularly to movement of the gasket. After the pressure has been increased to the required maximum value and held for 1 hour, the pressure is to be decreased to 0 psi while observations are made for leakage. The pressure is again to be slowly increased to the value specified in 10.10.2.2.1 and held for 1 more hour while observations are made for leakage and the leakage measurement is made.

The use of noncombustible compressed gas to increase the pressure in a water filled system is an acceptable test procedure.

A.10.10.2.2.4(1) New pipe laid with rubber gasketed joints should, if the workmanship is satisfactory, have no leakage at the joints. Unsatisfactory amounts of leakage usually result from twisted, pinched, or cut gaskets. However, some leakage might result from small amounts of grit or small imperfections in the surfaces of the pipe joints.

A.10.10.2.2.4(2) The use of a blind flange or skillet is preferred for use when hydrostatically testing segments of new work. Metal seated valves are susceptible to developing slight imperfections during transport, installation, and operation and thus can be likely to leak more than 1 fl oz (30 ml) per inch of valve diameter per hour. For this reason, the blind flange should be used when hydrostatically testing.

A.11.2.2.8 The additional pressure that is needed at the level of the water supply to account for sprinkler elevation is 0.433 psi/ft (0.098 bar/m) of elevation above the water supply.

A.11.2.3.1.1 Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that can include submitted fire testing, calculations, or results from appropriate computational models.

Recommended water supplies anticipate successful sprinkler operation. Because of the small but still significant number of uncontrolled fires in sprinklered properties, which have various causes, there should be an adequate water supply available for fire department use.

A.11.2.3.1.7 When a light hazard occupancy, such as a school, contains separate ordinary hazard storage rooms no more than 400 ft^2, the hose stream demand would be that required for a light hazard occupancy.

A.11.2.3.1.8(3) This section is included to compensate for possible delay in operation of sprinklers from fires in combustible concealed spaces found in wood frame, brick veneer, and ordinary construction.

A.11.2.3.1.8(4)(b) Composite wood joists are not considered solid wood joists for the purposes of this section. Their web members are too thin and easily penetrated to adequately compartment a fire in an unsprinklered space. Application of this item is not affected by the depth of the joist channel except in determining the volume.

A.11.2.3.1.8(4)(c) This exception is intended to apply only when the exposed materials in the space are limited combustible materials or fire retardant–treated wood as defined in NFPA 703, *Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials.*

A.11.2.3.2.1.1 The situation frequently arises where a small area of a higher hazard is surrounded by a lesser hazard. For example, consider a 600-ft^2 area consisting of 10-ft high on-floor storage of cartoned solid plastic commodities surrounded by a plaster injection molding operation in a 15-ft high building. In accordance with Chapter 12, the density required for the plastic storage must meet the requirements for extra hazard (Group 1) occupancies. The injection molding operation should be considered an ordinary hazard (Group 2) occupancy. In accordance with Chapter 11, the corresponding discharge densities should be 0.3 gpm/ft^2 over 2500 ft^2 for the storage and 0.2 gpm/ft^2 over 1500 ft^2 for the remainder of the area. (Also see Chapter 11 for the required minimum areas of operation.)

If the storage area is not separated from the surrounding area by a wall or partition *(see 11.1.2),* then the size of the operating area is determined by the higher hazard storage.

For example, the operating area is 2500 ft^2. The system must be able to provide the 0.3-gpm/ft^2 density over the storage area and 15 ft beyond. If part of the remote area is outside the 600 ft^2 plus the 15-ft overlap, then only 0.2 gpm/ft^2 is needed for that portion.

If the storage is separated from the surrounding area by a floor-to-ceiling/roof partition that is capable of preventing heat from a fire on one side from fusing sprinklers on the other side, then the size of the operating area is determined by the occupancy of the surrounding area. In this example, the design area is 1,500 ft^2. A 0.30-gpm/ft^2 density is needed within the separated area with 0.20 gpm/ft^2 in the remainder of the remote area.

A.11.2.3.2.2.2 It is not the intent of this exception to restrict the use of quick-response sprinklers in extra hazard occupancies but rather to indicate that the areas and densities shown in Figure 11.2.3.1.5 might not be appropriate for use with quick-response sprinklers in those environments due to a concern with water supplies.

A.11.2.3.2.7 *Example 1.* A dry pipe sprinkler system (OH_2) in a building with a ceiling slope exceeding two in 12 in. (16.6 percent slope). The initial area must be increased 30 percent for the dry pipe system and the resulting area an additional 30 percent for the roof slope. If the point 0.2 gpm/ft^2 (8.2 mm/min) over 1500 ft^2 (139 m^2) is chosen from Figure 11.2.3.1.5, the 1500-ft^2 (139-m^2) area is increased 450 ft^2 (42 m^2) to 1950 ft^2 (181 m^2), which is then further increased 585 ft^2 (54 m^2). The final discharge criterion is then 0.2 gpm/ft^2 (8.2 mm/min) over 2535 ft^2 (236 m^2).

Example 2. A wet pipe sprinkler system (light hazard) in a building with a 16 ft 8 in. ceiling and a slope exceeding two in 12 in. (16.6 percent slope) employs quick-response sprinklers qualifying for a 30 percent reduction as permitted by 11.2.3.2.3. The initial area must be increased 30 percent for the ceiling slope and the resulting area decreased 30 percent for quick-response sprinklers. It does not matter if the reduction is applied first. If a discharge density of 0.1 gpm/ft^2 (4.1 mm/min) over 1500 ft^2 (139 m^2) is chosen from Figure 11.2.3.1.5, the 1500 ft^2 (139 m^2) is increased 450 ft^2 (42 m^2), resulting in 1950 ft^2 (181 m^2), which is then decreased 585 ft^2 (54 m^2). The final design is 0.1 gpm/ft^2 (4.1 mm/min) over 1365 ft^2 (126.8 m^2).

A.11.2.3.3.1 This subsection allows for calculation of the sprinklers in the largest room, so long as the calculation produces the greatest hydraulic demand among selection of rooms and communicating spaces. For example, in a case where the largest room has four sprinklers and a smaller room has two sprinklers but communicates through unprotected openings with three other rooms, each having two sprinklers, the smaller room and group of communicating spaces should also be calculated.

Corridors are rooms and should be considered as such.

Walls can terminate at a substantial suspended ceiling and need not be extended to a rated floor slab above for this section to be applied.

A.11.2.3.4.2 This section is intended to apply to all types of systems including dry pipe and preaction systems.

A.11.2.3.5.1 The protection area for residential sprinklers with extended coverage areas is defined in the listing of the sprinkler as a maximum square or rectangular area. Listing information is presented in even 2-ft (0.61-m) increments from 12 ft to 20 ft (3.6 m to 6.1 m) for residential sprinklers. When a sprinkler is selected for an application, its area of coverage must be equal to or greater than both the length and width of the hazard area. For example, if the hazard to be protected is a room 14 ft 6 in. (4.3 m) wide and 20 ft 8 in. (6.2 m) long, a sprinkler that is listed to protect an area of 16 ft × 22 ft (4.9 m × 6.8 m) must be selected. The flow used in the calculations is then selected as the flow required by the listing for the selected coverage. *(See Figure A.11.2.3.5.1.)*

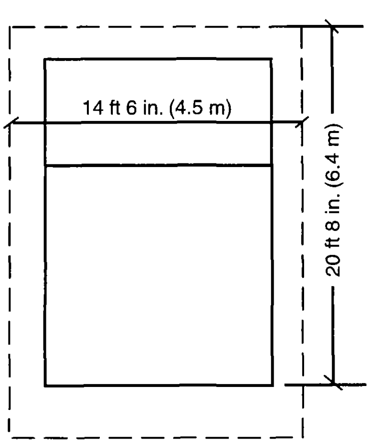


FIGURE A.11.2.3.5.1 Determination of Protection Area of Coverage for Residential Sprinklers.

A.11.2.3.5.2 In Figure A.11.2.3.5.2, calculate the area indicated by the heavy outline and X. The circle indicates sprinklers.

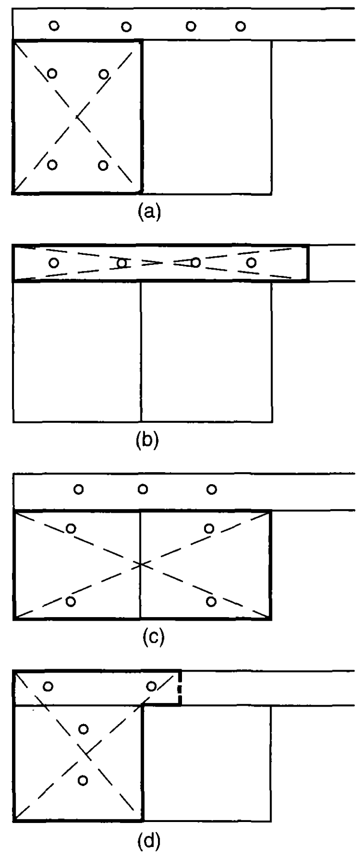


FIGURE A.11.2.3.5.2 Examples of Design Area for Dwelling Units.

A.11.2.3.7.1 If the system is a deluge type, then all the sprinklers need to be calculated even if they are located on different building faces.

A.12.1.4 Wet systems are recommended for storage occupancies. Dry pipe systems should be permitted only where it is impractical to provide heat.

A.12.1.4.2 Wet systems are recommended for rack storage occupancies. Dry systems are permitted only where it is impractical to provide heat. Preaction systems should be considered for rack storage occupancies that are unheated, particularly where in-rack sprinklers are installed or for those occupancies that are highly susceptible to water damage.

A.12.1.5 Where high temperature–rated sprinklers are installed at the ceiling, high temperature–rated sprinklers also should extend beyond storage in accordance with Table A.12.1.5.

A.12.1.8 In a dry pipe system, the area increase of 30 percent should be compounded [e.g., 2000 ft^2 (186 m^2) (1.67 for low-temperature sprinklers and 1.3 for dry pipe systems) = 4343 ft^2 (403.5 m^2) total area]. Where dry pipe systems are used in existing installations, the areas of operation indicated by the tables should be increased by 30 percent.

Table A.12.1.5 Extension of Installation of High-Temperature Sprinklers over Storage

Design Area for High Temperature–Rated Sprinklers		Distance Beyond Perimeter of High-Hazard Occupancy for High Temperature–Rated Sprinklers	
ft^2	m^2	ft	m
2000	185.8	30	9.14
3000	278.7	40	12.2
4000	371.6	45	13.72
5000	464.5	50	15.24
6000	557.4	55	16.76

A.12.1.9 Idle pallet storage introduces a severe fire condition. Stacking idle pallets in piles is the best arrangement of combustibles to promote rapid spread of fire, heat release, and complete combustion. After pallets are used for a short time in warehouses, they dry out and edges become frayed and splintered. In this condition they are subject to easy ignition from a small ignition source. Again, high piling increases considerably both the challenge to sprinklers and the probability of involving a large number of pallets when fire occurs. Therefore, it is preferable to store pallets outdoors where possible.

A fire in stacks of idle plastic or wooden pallets is one of the greatest challenges to sprinklers. The undersides of the pallets create a dry area on which a fire can grow and expand to other dry or partially wet areas. This process of jumping to other dry, closely located, parallel, combustible surfaces continues until the fire bursts through the top of the stack. Once this happens, very little water is able to reach the base of the fire. The only practical method of stopping a fire in a large concentration of pallets with ceiling sprinklers is by means of prewetting. In high stacks, this cannot be done without abnormally high water supplies. The storage of empty wood pallets should not be permitted in an unsprinklered warehouse containing other storage.

A.12.1.9.1.1 See Table A.12.1.9.1.1.

A.12.1.9.1.2 No additional protection is necessary, provided the requirements of 12.1.9.1.2 are met.

A.12.1.13 The reasons for using larger orifice sprinklers in storage situations are based on a number of fire tests in recent years that continue to show an advantage of the larger orifice (K-11.2 and K-16.8) sprinklers over the K-5.6 and even the K-8 orifice sprinklers. Following are four sets of fire test comparisons using constant densities. *[See Table A.12.1.13(a) and Table A.12.1.13(b)].*

(1) K-5.6 vs. K-11.2
   (a) Commodity — idle wood two-way pallets
   (b) 2 stacks × 3 stacks × 8 ft high
   (c) Ceiling height — 30 ft
   (d) Density — constant 0.30 gpm/ft^2
   (e) Test #1 — 165°F rated, K-11.2 sprinklers
   (f) Test #2 — 165°F rated, K-5.6 sprinklers
   (g) Test #1 results — 4 A.S. operated
   (h) Test #2 results — 29 A.S. operated, less fire control and greater temperatures
(2) K-8.0 vs. K-11.2 vs. K-16.8
   (a) Commodity — idle wood four-way pallets
   (b) Two stacks × three stacks × 12 ft high
   (c) Ceiling height — 30 ft
   (d) Density — constant 0.6 gpm/ft^2
   (e) Test #1 — 286°F rated, K-8 sprinklers
   (f) Test #2 — 165°F rated, K-11.2 sprinklers
   (g) Test #3 — 165°F rated, K-16.8 sprinklers
   (h) Test #1 results — 10 A.S. operated, 658°C maximum steel temperature, fire spread to all sides
   (i) Test #2 results — 13 A.S. operated, 94°C maximum steel temperature, fire spread to three sides
   (j) Test #3 results — 6 A.S. operated, 54°C maximum steel temperature, fire spread (just reached) one side

Table A.12.1.9.1.1 Recommended Clearance Between Outside Idle Pallet Storage and Building

Wall Construction		Minimum Distance of Wall from Storage of					
		Under 50 Pallets		50 to 200 Pallets		Over 200 Pallets	
Wall Type	Openings	ft	m	ft	m	ft	m
Masonry	None	0	0	0	0	0	0
	Wired glass with outside sprinklers and 1-hour doors	0	0	10	3.1	20	6.1
	Wired or plain glass with outside sprinklers and ¾-hour doors	10	3.1	20	6.1	30	9.1
Wood or metal with outside sprinklers		10	3.1	20	6.1	30	9.1
Wood, metal, or other		20	6.1	30	9.1	50	15.2

Notes:
1. Fire-resistive protection comparable to that of the wall also should be provided for combustible eaves lines, vent openings, and so forth.
2. Where pallets are stored close to a building, the height of storage should be restricted to prevent burning pallets from falling on the building.
3. Manual outside open sprinklers generally are not a reliable means of protection unless property is attended to at all times by plant emergency personnel.
4. Open sprinklers controlled by a deluge valve are preferred.

Table A.12.1.13(a) Ceiling Type

	Ceiling Type	Sprinkler Distance Below Ceiling (in.)	Time to Activation (seconds)	Size of Fire at Activation (Btu/s)
Fast-growing fire	Insulated deck	1	76	450
	Steel	1	97	580
	Wood	1	71	420
	Insulated deck	12	173	1880
	Steel	12	176	1930
	Wood	12	172	1900
Slow-growing fire	Insulated deck	1	281	220
	Steel	1	375	390
	Wood	1	268	200
	Insulated deck	12	476	630
	Steel	12	492	675
	Wood	12	473	620

Table A.12.1.13(b) Ceiling Arrangement

Situation	Fire	Time to Activate Sprinkler (seconds)	Fire Size at Time of Activation (Btu/s)
Ceiling with pocket	Fast	86 to 113	585
Sprinkler 12 in. below ceiling	Fast	172 to 176	1880 to 1900
Ceiling with pocket	Slow	288 to 395	490
Sprinkler 12 in. below ceiling	Slow	473 to 492	620 to 675

(3) K-5.6 vs. K-16.8
 (a) Commodity — FMRC standard plastic commodity rack style 9 ft high
 (b) Ceiling height — 30 ft
 (c) Density —0.45 gpm/ft^2
 (d) Test #1 — K-5.6 orifice sprinklers
 (e) Test #2 — K-16.8 orifice sprinklers
 (f) Test #1 results — 29 A.S. operated, 14 pallet loads consumed
 (g) Test #2 results — 5 A.S. operated, 2 pallet loads consumed

(4) K-8.0 vs. K-16.8
 (a) Commodity — FMRC standard plastic commodity rack stage 14 ft high
 (b) Ceiling height — 25 ft
 (c) Density — 0.60 gpm/ft^2
 (d) Test #1 — K-8.0 sprinklers
 (e) Test #2 — K-16.8 sprinklers
 (f) Test #1 results — 29 A.S. operated, 25 pallet loads consumed
 (g) Test #2 results — 7 A.S. operated, 4 pallet loads consumed

On an equal density basis the fire test comparisons show the advantage of the larger orifices. A possibly even bigger advantage can be seen when investigating the performance of larger orifice sprinklers in the real world condition of high initial operating pressures.

The volume of water discharged through the larger K-factor for the initial sprinklers has three significant effects.

(1) First, the increase in sheer volume flowing through the larger orifice enhances performance. For example, a 165 psi initial operating pressure would provide 102.8 gpm from a K-8, while the K-16.8 will discharge 215.8 gpm.
(2) Second, fire testing at high pressures (100+ psi) with K-5.6 and K-8 (when high fire updrafts occur) have shown less water penetration and more sprinkler skipping. When fire testing the K-11 and K-16.8 sprinklers at 100+ psi, more water penetration is evident and little or no sprinkler skipping has occurred.
(3) Third, with such high initial discharge rates among K-16.8 sprinklers, the friction loss in the supply pipes would be greater. This would result in lower initial pressures than a K-8 as well as being farther down the water supply curve with greater flows resulting in lower initial operating pressures.

Figure A.12.1.13 highlights the differences of the K-8 and K-16.8 initial operating pressures.

The higher flow rate of the K-16.8 sprinkler results in greater friction losses in the initial operating heads as compared to the K-8. Combined with the lower pressure available on the water supply curve, the end result is a self-regulating orifice size allowing greater initial pressures without a negative impact.

Table A.12.1.13(c) summarizes the paper product testing.

The results: The tests indicated that even at a high temperature of 286°F, the K-8 sprinklers operating at higher pressures were not effective in controlling the fire. Conversely, the K-16.8 was able to control the fire at the lower temperature (155°F), by operating sooner, and at lower, self-regulating flowing pressures.

Conclusions: The larger K-factor of the K-16.8 is not affected by high initial operating pressures. In fact, the protection is enhanced, providing better fire protection.

The ability to use lower rated temperatures, such as 155°F in lieu of 286°F, shows that the performance of the initial operating sprinklers is effective in controlling the fire. Therefore, using high temperature heads to reduce the number of surrounding rings of sprinklers to open is not necessary when using the K-16.8 technology.

In short, the K-16.8 proved highly effective when subjected to high initial operating pressures.

A.12.2.1.2 Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that can include submitted fire testing, calculations, or results from appropriate computational models.

Recommended water supplies anticipate successful sprinkler operation. Because of the small but still significant number of uncontrolled fires in sprinklered properties, which have various causes, there should be an adequate water supply available for fire department use.

A.12.2.2.1 The following procedure should be followed in determining the proper density and area as specified in Chapter 12:

(1) Determine the commodity class.
(2) Select the density and area of application.
(3) Adjust the required density for storage height.
(4) Increase the operating area by 30 percent where a dry pipe system is used.

Table A.12.1.13(c) Paper Product Testing Results

Test Date	3/25/98	3/18/98[a]	4/4/98	6/4/98[b]
Sprinklers	K-8	K-8	K-11	K-17-231
Temperature	286°F	286°F	165°F	155°F
Storage Type	4 tier pyramid	5 tier pyramid	4 tier pyramid	5 tier pyramid
Storage Height	16 ft	22 ft	16 ft	22 ft
Ceiling Height	30 ft	31 ft	30 ft	31 ft
Sprinkler Flow Pressure	22.6 psi	175 psi	11.9 psi	130 psi
Number of Operated Sprinklers	15	2	10	2
Peak Gas Temperature	—	868°F	—	424°F
Peak Steel Temperature	—	421°F	—	113°F
Fire Spread Across Aisle (30 in.)	N/A	Yes	N/A	No

[a]This test was run with a fire brigade response of 20:00 minutes.
[b]This test was run with a fire brigade response of 7:00 minutes.

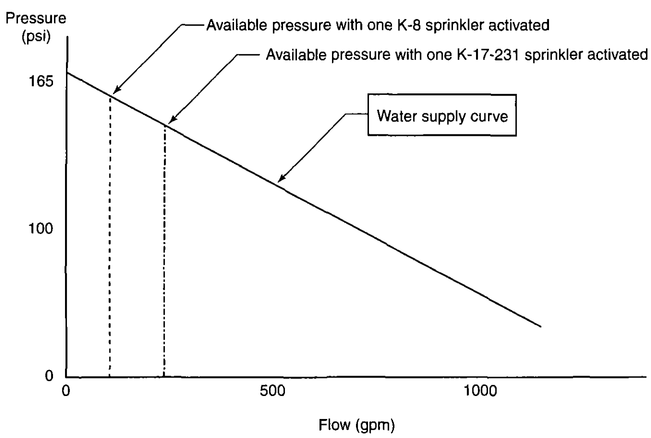


FIGURE A.12.1.13 Available Pressure Comparison.

(5) Satisfy the minimum densities and areas.
Example:
Storage — greeting cards in boxes in cartons on pallets
Height — 22 ft (6.7 m)
Clearance — 6 ft (1.8 m)
Sprinklers — ordinary temperature
System type — dry
(a) Classification — Class III
(b) Selection of density/area — 0.225 gpm/ft^2 (9.2 mm/min) over 3000 ft^2 (279 m^2)
(c) Adjustment for height of storage — 1.15 × 0.225 gpm/ft^3 = 0.259 gpm/ft^2 (10.553 mm/min), rounded up to 0.26 gpm/ft^2 (10.6 mm/min)
(d) Adjustment of area of operation for dry system — 1.3 × 3000 ft^2 = 3900 ft^2 (363 m^2)
(e) Confirmation that minimum densities and areas have been achieved

The minimum design density for a dry sprinkler system is 0.15 gpm/ft^2 over 2600 ft^2 (6.1 mm/min over 242 m^2) for Class III.

The corresponding minimum density at 3000 ft^2 (279 m^2) is 0.17 gpm/ft^2 (6.9 mm/min) (satisfied); 1.3 × 3000 ft^2 = 3900 ft^2 (363 m^2), 0.17 gpm/ft^2 (6.9 mm/min) over 3900 ft^2 (363 m^2).

The design density and area of application equals 0.26 gpm/ft^2 over 3900 ft^2 (10.6 mm/min over 363 m^2).

A.12.2.2.1.1(3) Full-scale tests show no appreciable difference in the number of sprinklers that open for either nonencapsulated or encapsulated products up to 15 ft (4.6 m) high. Test data is not available for encapsulated products stored higher than 15 ft (4.6 m). However, in rack storage tests involving encapsulated storage 20 ft (6.1 m) high, increased protection was needed over that for nonencapsulated storage.

The protection specified contemplates a maximum of 10-ft (3-m) clearances from top of storage to sprinkler deflectors for storage heights of 15 ft (4.6 m) and higher.

A.12.2.3.1 The densities and area of application have been developed from fire test data. Most of these tests were conducted with K-8 orifice sprinklers and 80-ft^2 or 100-ft^2 (7.4-m^2 or 9.3-m^2) sprinkler spacing. These and other tests have indicated that, with densities of 0.4 gpm/ft^2 (16.3 mm/min) and higher, better results are obtained with K-8 orifice and 70-ft^2 to 100-ft^2 (7.4-m^2 to 9.3-m^2) sprinkler spacing than where using K-5.6 orifice sprinklers at 50-ft^2 (4.6-m^2) spacing. A discharge pressure of 100 psi (6.9 bar) was used as a starting point on one of the fire tests. It was successful, but has a 1½-ft (0.5-m) clearance between the top of storage and ceiling sprinklers. A clearance of 10 ft (3 m) could have produced a different result due to the tendency of the higher pressure to atomize the water and the greater distance that the fine water droplets had to travel to the burning fuel.

Table A.12.2.3.1 explains and provides an example of the method and procedure to follow in using this standard to determine proper protection for Group A plastics.

Table A.12.2.3.1 Metric Conversion Factors for Examples

To Convert from	to	Multiply by
feet (ft)	meters (m)	0.3048
square feet (ft^2)	square meters (m^2)	0.0929
gallons/minute (gpm)	liters/second (L/sec)	0.0631
gallons per minute per square foot (gpm/ft^2)	millimeters per minute (same as liters per minute per square meter) (mm/min)	40.746

Example 1. Storage is expanded, cartoned, stable, 15 ft (4.6 m) high in a 20-ft (6.1-m) building.

Answer 1. Column E — design density is 0.45 gpm/ft^2 (18.3 mm/min).

Example 2. Storage is nonexpanded, unstable, 15 ft (4.6 m) high in a 20-ft (6.1-m) building.

Answer 2. Column A— design density is listed as 0.25 gpm/ft^2 (10.2 mm/min); however, it is also possible that the storage can be 12 ft (3.66 m) in this 20-ft (6.1-m) building, which would require a design density of 0.3 (12.2 mm/min). Unless the owner can guarantee that the storage will always be 15 ft (4.6 m), the design density = 0.3 gpm/ft^2 (12.2 mm/min).

Example 3. Storage is a nonexpanded, stable 15-ft (4.6-m) fixed-height unit load, one high, in an 18-ft (5.5-m) building.

Answer 3. Column A — design density is 0.25 gpm/ft^2 (10.2 mm/min). Note that this design density does not increase to 0.3 gpm/ft^2 (12.2 mm/min) as in the previous example because of the use of a fixed-height unit load. The storage height will never be 12 ft (3.66 m). It will always be 15 ft (4.6 m).

Example 4. Storage is expanded, exposed, unstable, 20 ft (6.1 m) high in a 27-ft (8.2-m) building.

Answer 4. Column C — design density is 0.7 gpm/ft^2 (28.5 mm/min). Note that other lower storage heights should also be checked, but they reveal the same, or lower, densities [0.7 gpm/ft^2 and 0.6 gpm/ft^2 (28.5 mm/min and 24.5 mm/min)], so the design density remains at 0.7 gpm/ft^2 (28.5 mm/min).

Example 5. Storage is expanded, cartoned, unstable, 17 ft (5.2 m) high in 32-ft (9.75-m) building.

Answer 5. Column D — 15-ft (4.6 m) storage in a 32-ft (9.75-m) building would be 0.55 gpm/ft^2 (22.4 mm/min); 20-ft (6.1-m) storage in a 32-ft (9.75-m) building would be 0.7 gpm/ft^2 (28.5 mm/min). Interpolation for 17-ft (5.2-m) storage is as follows:

$$0.7 - 0.55 = 0.15$$

$$\frac{0.15}{(20-15)} = 0.03$$

$$0.03 \times (17-15) = 0.06$$

$$0.55 + 0.06 = 0.61$$

Design density = 0.61 gpm/ft^2 (24.9 mm/min)

Example 6. Storage is expanded, exposed, stable, 22 ft (6.71 m) high in a 23½-ft (7.16-m) building.

Answer 6. Column B — could interpolate between 0.6 gpm/ft^2 and 0.75 gpm/ft^2 (24.5 mm/min and 30.6 mm/min); however, this would be a moot point since the density for 15-ft (4.6-m) storage in this 23½-ft (7.16-m) building would be 0.8 gpm/ft^2 (32.6 mm/min). Unless the owner can guarantee 22-ft (6.71-m) storage, the design density is 0.8 gpm/ft^2 (32.6 mm/min). If the owner can, in a manner acceptable to the authority having jurisdiction, guarantee 22-ft (6.71-m) storage, the interpolation would yield a design density of 0.66 gpm/ft^2 (26.9 mm/min).

Example 7. Storage is nonexpanded, stable, exposed, 13½ ft (4.1 m) high in a 15-ft (4.6-m) building.

Answer 7. Column E — 12-ft (3.66-m) storage in a 15-ft (4.6-m) building would be extra hazard, Group 2 [0.4 gpm/ft^2 over 2500 ft^2 (16.3 mm/min over 230 m^2)].

Storage 15 ft (4.6 m) high in a 15-ft (4.6-m) building would be 0.45 gpm/ft^2 (18.3 mm/min). Interpolation for 13½-ft (4.1-m) storage is as follows:

$$0.45 - 0.4 = 0.05$$

$$\frac{0.05}{(15-12)} = 0.017$$

$$0.017 \times (13.5-12) = 0.026$$

$$0.4 + 0.026 = 0.426$$

Design density = 0.426 gpm/ft^2 (17.4 mm/min)

A.12.2.3.1.1 Two direct comparisons between ordinary temperature- and high temperature-rated sprinklers are possible, as follows:

(1) With nonexpanded polyethylene 1-gal (3.8-L) bottles in corrugated cartons, a 3-ft (0.9-m) clearance, and the same density, approximately the same number of sprinklers operated (nine at high temperature versus seven at ordinary temperature).
(2) With exposed, expanded polystyrene meat trays, a 9.5-ft (1.9-m) clearance, and the same density, three times as many ordinary temperature-rated sprinklers operated as did high temperature-rated sprinklers (11 at high temperature versus 33 at ordinary temperature).

The cartoned plastics requirements of this standard are based to a great extent on test work that used a specific commodity — 16-oz (0.473-L) polystyrene plastic jars individually separated by thin carton stock within a large corrugated carton [3½ ft^2 (0.32 m^2)]. *[See Figure A.12.2.3.1.1(a).]*

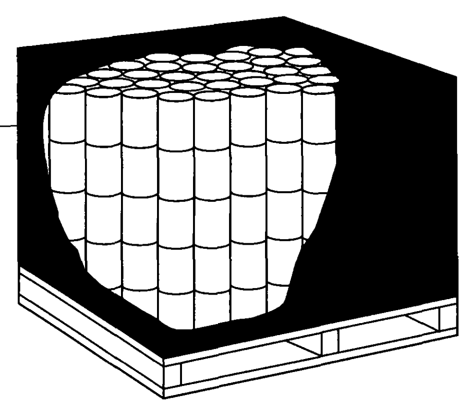


FIGURE A.12.2.3.1.1(a) Corrugated Carton Containing Individually Separated Plastic Jars.

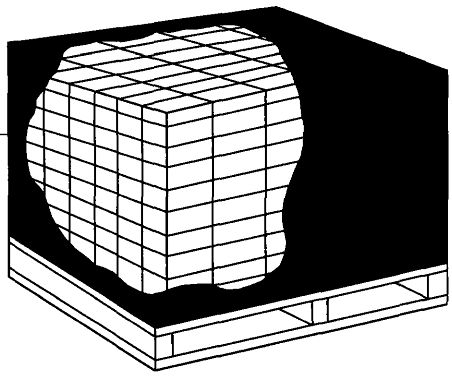


FIGURE A.12.2.3.1.1(b) Corrugated Carton Containing Plastic Pieces Individually Separated by Carton Material.

Other Group A plastic commodities can be arranged in cartons so that they are separated by multiple thicknesses of carton material. In such arrangements, less plastic becomes involved in the fire at any one time. This could result in a less vigorous fire that can be controlled by Class IV commodity protection.

Other situations exist in which the plastics component is surrounded by several layers of less hazardous material and is therefore temporarily protected or insulated from a fire involving adjacent plastic products. Such conditions also could produce a less vigorous fire and be successfully handled by Class IV protection. *[See Figure A.12.2.3.1.1(b).]*

The decision to protect as a Class IV commodity, however, should be made only based on experienced judgment and only with an understanding of the consequences of underprotecting the storage segment.

A.12.2.3.1.2 There are few storage facilities in which the commodity mix or storage arrangement remains constant, and a designer should be aware that the introduction of different materials can change protection requirements considerably. Design should be based on higher densities and areas of application, and the various reductions allowed should be applied cautiously. For evaluation of existing situations, however, the allowances can be quite helpful.

A.12.2.3.1.5 An evaluation for each field situation should be made to determine the worst applicable height-clearance relationship that can be expected to appear in a particular case. Fire tests have shown that considerably greater demands occur where clearance is 10 ft (3.1 m) as compared to 3 ft (0.9 m) and where a pile is stable as compared to an unstable pile. Since a system is designed for a particular clearance, the system could be inadequate when significant areas do not have piling to the design height and larger clearances exist between stock and sprinklers. This can also be true where the packaging or arrangement is changed so that stable piling is created where unstable piling existed. Recognition of these conditions is essential to avoid installation of protection that is inadequate or becomes inadequate because of changes.

No tests were conducted simulating a peaked roof configuration. However, it is expected that the principles of Chapter 12 still apply. The worst applicable height-clearance relationship that can be expected to occur should be found, and protection should be designed for it. If storage is all at the same height, the worst height-clearance relationship creating the greatest water demand would occur under the peak. If commodities are stored higher under the peak, the various height-clearance relationships should be tried and the one creating the greatest water demand used for designing protection.

A.12.2.3.1.6 Test data is not available for all combinations of commodities, storage heights, and clearances. Some of the protection criteria in this standard are based on extrapolations of test data for other commodities and storage configurations, as well as available loss data.

For example, there is very limited test data for storage of expanded plastics higher than 20 ft (6.1 m). The protection criteria in this standard for expanded plastics higher than 20 ft (6.1 m) are extrapolated from test data for expanded plastics storage 20 ft (6.1 m) and less in height and test data for unexpanded plastics above 20 ft (6.1 m).

Further examples can be found in the protection criteria for clearances up to 15 ft (4.6 m). Test data is limited for clearances greater than 10 ft (3.1 m). It should be assumed that, if protection is adequate for a given storage height in a building of a given height, the same protection will protect storage of any lesser height in the same building. For example, protection adequate for 20-ft (6.1-m) storage in a 30-ft (9.1-m) building [10-ft (3.1-m) clearance] would also protect 15-ft (4.6-m) storage in a 30-ft (9.1-m) building [15-ft (4.6-m) clearance]. Therefore, the protection criteria in Table 12.2.3.1.6 for 15-ft (4.6-m) clearance are based on the protection criteria for storage 5 ft (1.5 m) higher than the indicated height with 10-ft (3.1-m) clearance.

Table 12.2.3.1.6 is based on tests that were conducted primarily with high temperature–rated, K-8 orifice sprinklers. Other tests have demonstrated that, where sprinklers are used with orifices greater than K-8, ordinary-temperature sprinklers are acceptable.

A.12.3.1.2 The fire protection system design should consider the maximum storage height. For new sprinkler installations, maximum storage height is the usable height at which commodities can be stored above the floor while the minimum required unobstructed space below sprinklers is maintained. Where evaluating existing situations, maximum storage height is the maximum existing storage height if space between the sprinklers and storage is equal to or greater than that required.

A.12.3.1.2.2 Information for the protection of Classes I, II, III, and IV commodities was extrapolated from full-scale fire tests that were performed at different times than the tests that were used to develop the protection for plastic commodities. It is possible that, by selecting certain points from the tables (and after applying the appropriate modifications), the protection specified by 12.3.2.4.1 exceeds the requirements of 12.3.3. In such situations, the protection specified for plastics, although less than that required by the tables, can adequately protect Classes I, II, III, and IV commodities.

This section also allows storage areas that are designed to protect plastics to store Classes I, II, III, and IV commodities without a re-evaluation of fire protection systems.

A.12.3.1.8.1 Detection systems, concentrate pumps, generators, and other system components that are essential to the operation of the system should have an approved standby power source.

A.12.3.1.12 Where the ceiling is more than 10 ft (3.1 m) above the maximum height of storage, a horizontal barrier should be installed above storage with one line of sprinklers

under the barrier for Classes I, II, and III commodities and two lines of sprinklers under the barrier for Class IV commodities. In-rack sprinkler arrays should be installed as indicated in Table 12.3.4.1.1 and Figure 12.3.4.4.1.1(a) through Figure 12.3.4.4.1.1(j).

Barriers should be of sufficient strength to avoid sagging that interferes with loading and unloading operations.

Horizontal barriers are not required to be provided above a Class I or Class II commodity with in-rack sprinkler arrays in accordance with Figure 12.3.4.4.1.1(a) and Figure 12.3.4.4.1.1(b) provided one line of in-rack sprinklers is installed above the top tier of storage.

A.12.3.2.1.1.1 Bulkheads are not a substitute for sprinklers in racks. Their installation does not justify reduction in sprinkler densities or design operating areas as specified in the design curves.

A.12.3.2.1.2 Data indicates that the sprinkler protection criteria in Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(g) is ineffective, by itself, for rack storage with solid shelves, if the required flue spaces are not maintained. Use of Figure 12.3.2.1.2(a) through Figure 12.3.2.1.2(g) along with the additional provisions that are required by this standard, can provide acceptable protection.

A.12.3.2.1.2.1 The aisle width and the depth of racks are determined by material-handling methods. The widths of aisles should be considered in the design of the protection system. Storage in aisles can render protection ineffective and should be discouraged.

A.12.3.2.1.6 Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that can include submitted fire testing, calculations, or results from appropriate computational models.

Recommended water supplies anticipate successful sprinkler operation. Because of the small but still significant number of uncontrolled fires in sprinklered properties, which have various causes, there should be an adequate water supply available for fire department use.

A.12.3.2.3 ESFR sprinklers are designed to respond quickly to growing fires and deliver heavy discharge to suppress fires rather than to control them. ESFR sprinklers should not be relied on to provide suppression if they are used outside the design parameters.

While these sprinklers are intended primarily for use in high-pile storage situations, this section permits their use and extension into adjacent portions of an occupancy that might have a lesser classification.

Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Chapter 12 is satisfied for each storage area.

Design parameters were determined from a series of full-scale fire tests that were conducted as a joint effort between Factory Mutual Research Corporation and the National Fire Protection Research Foundation. (Copies of the test reports are available from the NFPRF.)

A.12.3.2.4.2.1 Spacing of sprinklers on branch lines in racks in the various tests demonstrates that maximum spacing as specified is proper.

A.12.3.2.4.2.2 In-rack sprinklers at one level only for storage up to and including 25 ft (7.6 m) in multiple-row racks should be located at the tier level nearest one-half to two-thirds of the storage height.

A.12.3.2.4.2.3 Where possible, it is recommended that in-rack sprinkler deflectors be located at least 6 in. (152.4 mm) above pallet loads.

A.12.3.2.4.2.4 Where possible, it is recommended that in-rack sprinklers be located away from rack uprights.

A.12.3.2.5.1.1 Slatting of decks or walkways or the use of open grating as a substitute for automatic sprinkler thereunder is not acceptable.

In addition, where shelving of any type is employed, it is for the basic purpose of providing an intermediate support between the structural members of the rack. As a result, it becomes almost impossible to define and maintain transverse flue spaces across the rack as required.

A.12.3.2.5.2.2 Where high-expansion foam is contemplated as the protection media, consideration should be given to possible damage to the commodity from soaking and corrosion. Consideration also should be given to the problems associated with the removal of the foam after discharge.

A.12.3.3.1.2 All rack fire tests of plastics were run with an approximate 10-ft (3.1-m) maximum clearance between the top of the storage and the ceiling sprinklers. Within 30-ft (9.1-m) high buildings, greater clearances above storage configurations should be compensated for by the addition of more in-rack sprinklers or the provision of greater areas of application, or both.

A.12.3.3.1.11 Appropriate area/density, other design criteria, and water supply requirements should be based on scientifically based engineering analyses that can include submitted fire testing, calculations, or results from appropriate computational models.

Recommended water supplies anticipate successful sprinkler operation. Because of the small but still significant number of uncontrolled fires in sprinklered properties, which have various causes, there should be an adequate water supply available for fire department use.

A.12.3.3.3 ESFR sprinklers are designed to respond quickly to growing fires and deliver heavy discharge to suppress fires rather than to control them. ESFR sprinklers should not be relied on to provide suppression if they are used outside the design parameters.

While these sprinklers are intended primarily for use in high-pile storage situations, this section permits their use and extension into adjacent portions of an occupancy that might have a lesser classification.

Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Chapter 12 is satisfied for each storage area.

Design parameters were determined from a series of full-scale fire tests that were conducted as a joint effort between Factory Mutual Research Corporation and the National Fire Protection Research Foundation. (Copies of the test reports are available from the NFPRF.)

A.12.3.3.5.1.1 Slatting of decks or walkways or the use of open grating as a substitute for automatic sprinkler thereunder is not acceptable.

In addition, where shelving of any type is employed, it is for the basic purpose of providing an intermediate support between the structural members of the rack. As a result, it be-

comes almost impossible to define and maintain transverse flue spaces across the rack as required.

A.12.3.4.1.1 Water demand for storage height over 25 ft (7.6 m) on racks without solid shelves separated by aisles at least 4 ft (1.2 m) wide and with more than 10 ft (3.1 m) between the top of storage and the sprinklers should be based on sprinklers in a 2000-ft^2 (186-m^2) operating area for double-row racks and a 3000-ft^2 (278.7-m^2) operating area for multiple-row racks discharging a minimum of 0.18 gpm/ft^2 (7.33 mm/min) for Class I commodities, 0.21 gpm/ft^2 (8.56 mm/min) for Classes II and III commodities, and 0.25 gpm/ft^2 (10.2 mm/min) for Class IV commodities for ordinary temperature–rated sprinklers or a minimum of 0.25 gpm/ft^2 (10.2 mm/min) for Class I commodities, 0.28 gpm/ft^2 (11.41 mm/min) for Classes II and III commodities, and 0.32 gpm/ft^2 (13.04 mm/min) for Class IV commodities for high temperature–rated sprinklers. (*See A.12.3.1.12 and A.12.3.4.4.1.3.*)

Where such storage is encapsulated, ceiling sprinkler density should be 25 percent greater than for nonencapsulated storage.

Data indicate that the sprinkler protection criteria in 12.3.4.1.1 is ineffective, by itself, for rack storage with solid shelves, if the required flue spaces are not maintained. Use of 12.3.4.1.1, along with the additional provisions that are required by this standard, can provide acceptable protection.

A.12.3.4.3 ESFR sprinklers are designed to respond quickly to growing fires and deliver heavy discharge to suppress fires rather than to control them. ESFR sprinklers should not be relied on to provide suppression if they are used outside the design parameters.

While these sprinklers are intended primarily for use in high-pile storage situations, this section permits their use and extension into adjacent portions of an occupancy that might have a lesser classification.

Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Chapter 12 is satisfied for each storage area.

Design parameters were determined from a series of full-scale fire tests that were conducted as a joint effort between Factory Mutual Research Corporation and the National Fire Protection Research Foundation. (Copies of the test reports are available from the NFPRF.)

A.12.3.4.4.1.1 Where storage tiers are not the same size on each side of the longitudinal flue, one side of the flue should be protected with sprinklers at the proper elevation above the load. The next level of sprinklers should protect the other side of the flue with the sprinklers at the proper elevation above that load as indicated in Figure A.12.3.4.4.1.1. The vertical spacing requirements for in-rack sprinklers specified in Table 12.3.4.1.1 and 12.3.3 for plastics should be followed.

A.12.3.4.4.1.2 In single-row racks with more than 10 ft (3.1 m) between the top of storage and the ceiling, a horizontal barrier should be installed above storage with one line of sprinklers under the barrier.

A.12.3.4.4.1.3 In multiple-row racks with more than 10 ft (3.1 m) between the maximum height of storage and ceiling, a horizontal barrier should be installed above storage with a level of sprinklers, spaced as stipulated for in-rack sprinklers, installed directly beneath the barrier. In-rack sprinklers should be installed as indicated in Figure 12.3.4.4.1.3(a) through Figure 12.3.4.4.1.3(c).

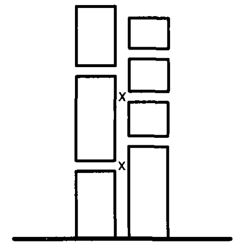


FIGURE A.12.3.4.4.1.1 Placement of In-Rack Sprinkler Where Rack Levels Have Varying Heights.

Data indicate that the sprinkler protection criteria in 12.3.4.4.1.3 is ineffective, by itself, for rack storage with solid shelves, if the required flue spaces are not maintained. Use of Table 12.3.4.1.3, along with the additional provisions that are required by this standard, can provide acceptable protection.

A.12.3.5.3 ESFR sprinklers are designed to respond quickly to growing fires and deliver heavy discharge to suppress fires rather than to control them. ESFR sprinklers should not be relied on to provide suppression if they are used outside the design parameters.

While these sprinklers are intended primarily for use in high-pile storage situations, this section permits their use and extension into adjacent portions of an occupancy that might have a lesser classification.

Storage in single-story or multistory buildings can be permitted, provided the maximum ceiling/roof height as specified in Chapter 12 is satisfied for each storage area.

Design parameters were determined from a series of full-scale fire tests that were conducted as a joint effort between Factory Mutual Research Corporation and the National Fire Protection Research Foundation. (Copies of the test reports are available from the NFPRF.)

A.12.3.5.4.1.3 *Figure (a)* — The protection area per sprinkler under barriers should be no greater than 80 ft^2 (7.44 m^2).

Figure (b) — The protection area per sprinkler under barriers should be no greater than 80 ft^2 (7.44 m^2).

Figure (c) — The protection area per sprinkler under barriers should be no greater than 50 ft^2 (4.65 m^2).

Figure (d) — The protection area per sprinkler under barriers should be no greater than 50 ft^2 (4.65 m^2).

Figure (e) — The protection area per sprinkler under barriers should be no greater than 50 ft^2 (4.65 m^2).

Figure (f) — The protection area per sprinkler under barriers should be no greater than 50 ft^2 (4.65 m^2).

A.12.4.2 The protection criteria in Table 12.4.2(a) through Table 12.4.2(d) have been developed from fire test data. Protection requirements for other storage methods are beyond the scope of this standard at the present time. From fire testing with densities of 0.45 gpm/ft^2 (18.3 mm/min) and higher, there have been indications that large-orifice sprinklers at greater than 50-ft^2 (4.6-m^2) spacing produce better results than the ½-in. (12.7-mm) orifice sprinklers at 50-ft^2 (4.6-m^2) spacing.

Table 12.4.2(a) and Table 12.4.2(c) are based on operation of standard sprinklers. Use of quick-response or other special sprinklers should be based on appropriate tests as approved by the authority having jurisdiction.

The current changes to Table 12.4.2(a) through Table 12.4.2(d) represent test results from rubber tire fire tests performed at the Factory Mutual Research Center.

Storage heights and configurations, or both, [e.g., automated material-handling systems above 30 ft (9.1 m)] beyond those indicated in the table have not had sufficient test data developed to establish recommended criteria. Detailed engineering reviews of the protection should be conducted and approved by the authority having jurisdiction.

A.12.6 This section provides a summary of the data developed from the tissue test series of full-scale roll paper tests conducted at the Factory Mutual Research Center in West Glocester, RI.

The test building is approximately 200 ft × 250 ft [50,000 ft² (4.65 km²)] in area, of fire-resistive construction, and has a volume of approximately 2.25 million ft³ (63,720 m³), the equivalent of a 100,000-ft² (9.29-km²) building 22.5 ft (6.86 m) high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft (9.1 m) high and the west section is 60 ft (18.29 m) high.

The tissue test series was conducted in the 30-ft (9.1-m) section, with clearances from the top of storage to the ceiling nominally 10 ft (3.1 m).

Figure A.12.6 illustrates a typical storage array used in the tissue series of tests.

The basic criteria used in judging test failure included one or more of the following:

(1) Firespread to the north end of the storage array
(2) Gas temperatures near the ceiling maintained at high levels for a time judged to be sufficient to endanger exposed structural steel
(3) Fire reaching the target stacks

Table A.12.6 outlines the tissue test results.

Fire tests have been conducted on 20-ft (6.1-m) and 25-ft (7.6-m) high vertical storage of tissue with 10-ft (3.1-m) and 5-ft (1.5-m) clear space to the ceiling in piles extending up to seven columns in one direction and six columns in the other direction. In these tests, target columns of tissue were located directly across an 8-ft (2.4-m) aisle from the main pile. Three tests were conducted using 17⁄32-in. (13.5-mm) 286°F (141°C) high-temperature sprinklers on a 100-ft² (9.3-m²) spacing and at constant pressures of 14 psi, 60 psi, and 95 psi (1 bar, 4.1 bar, and 6.6 bar), respectively. One test was run using 0.64-in. (16.3-mm) 286°F (141°C) high-temperature sprinklers on a 100-ft² (9.3-m²) spacing at a constant pressure of 50 psi (3.5 bar). Two tests were conducted following a scheduled decay from an initial pressure of 138 psi (9.5 bar) to a design point of 59 psi (4.1 bar) if 40 sprinklers opened. The significant characteristic of these fire tests was the rapid initial firespread across the surface of the rolls. Ceiling temperatures were controlled during the decaying pressure tests and during the higher constant pressure tests. With the exception of the 20-ft (6.1-m) high decaying pressure test, the extent of firespread within the pile could not be clearly established. Aisle jump was experienced, except at the 95-psi (6.6-bar) constant pressure, 20-ft (6.1-m) high decaying pressure, and large drop test. Water absorption and pile instability caused pile collapse in all tests. This characteristic should be considered where manually attacking a fire in tissue storage occupancies.

Available fire experience in roll tissue storage occupancies does not correlate well with the constant pressure full-scale fire tests with respect to the number of sprinklers operating and the extent of firespread. Better correlation is noted with the decaying pressure tests. Thirteen fires reported in storage occupancies with storage piles ranging from 10 ft to 20 ft (3.1 m to 6.1 m) high and protected by wet pipe sprinkler systems ranging from ordinary hazard design densities to design densities of 0.6 gpm/ft² (24.5 mm/min) were controlled with an average of 17 sprinklers. The maximum number of wet pipe sprinklers that opened was 45 and the minimum number was five, versus 88 and 26, respectively, in the constant pressure tests. Seventeen sprinklers opened in the 20-ft (6.1-m) high decaying pressure test. One actual fire in tissue storage provided with a dry pipe system opened 143 sprinklers but was reported as controlled.

One fire test was conducted with plastic-wrapped rolls of heavyweight kraft paper. The on-end storage was in a standard configuration, 20 ft (6.1 m) high with 9½-ft (2.9-m) clearance to ceiling sprinklers. The prescribed 0.3-gpm/ft² (12.2-mm/min) density controlled the firespread, but protection to roof steel was marginal to the point where light beams and joists might be expected to distort. A lower moisture content in the paper as a result of the protective plastic wrapping was considered to be the reason for the higher temperatures in this test as compared to a similar test where the rolls were not wrapped.

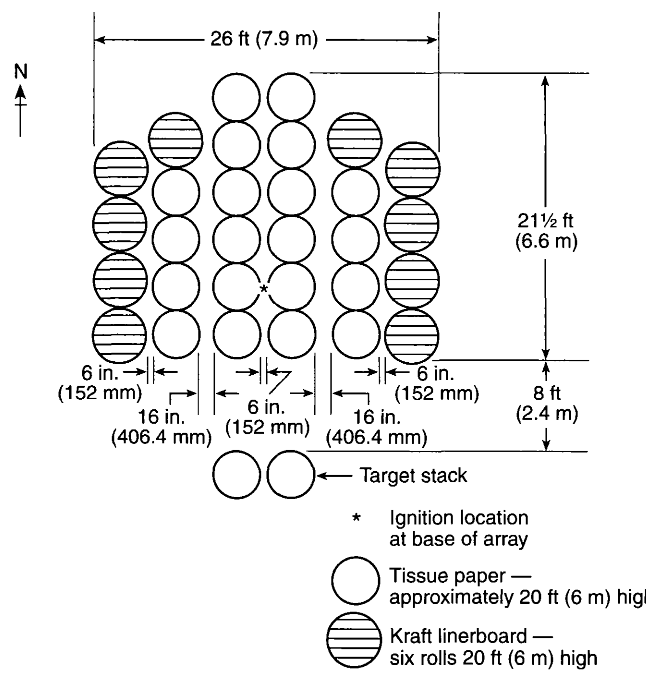


FIGURE A.12.6 Plan View of Typical Tissue Storage Array.

A.12.6.2 *Existing Systems.* Sprinkler systems protecting existing roll paper storage facilities should be evaluated in accordance with Table A.12.6.2(a) and Table A.12.6.2(b). While fire can be controlled by the protection shown in Table A.12.6.2(a) and Table A.12.6.2(b), greater damage can occur when the densities in Table A.12.6.2(a) and Table A.12.6.2(b) are used rather than those specified in Table 12.6.2.1.3(a) and Table 12.6.2.1.3(b).

Table A.12.6 Summary of Roll Paper Tissue Tests

	Test Number					
Test Specifications	**B1**[a]	**B2**	**B3**	**B4**	**B5**[b]	**B6**[b]
Test date	10/4/79	7/23/80	7/30/80	10/15/80	7/28/82	8/5/82
Paper type	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Stack height [ft-in. (m)]	21–10 (6.66)	20–0 (6.1)	21–8 (21.60)	18–6 (6.64)	19–10 (6.05)	25–3 (7.69)
Paper, banded	No	No	No	No	No	No
Paper, wrapped	No	No	No	No	No	No
Fuel array	Standard	Standard	Standard	Standard	Standard	Standard
Clearance to ceiling [ft-in. (m)]	8–2 (2.49)	10–0 (3.05)	8–4 (2.54)	11–6 (3.51)	5–2 (1.58)	4–9 (1.45)
Clearance to sprinklers [ft-in. (m)]	7–7 (2.31)	9–5 (2.87)	7–9 (2.36)	10–9 (3.28)	4–7 (1.40)	4–2 (1.27)
Sprinkler orifice [in. (mm)]	17⁄32 (13.5)	17⁄32 (13.5)	17⁄32 (13.5)	0.64 (16.33)	17⁄32 (13.5)	17⁄32 (13.5)
Sprinkler temperature rating [F (°C)]	280 (138)	280 (138)	280 (138)	280 (138)	280 (138)	280 (138)
Sprinkler spacing [ft × ft (m × m)]	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)	10 × 10 (3.05 × 3.05)
Water pressure [psi (bar)]	14 (0.9)[c]	60 (4.1)	95 (6.6)	50 (3.4)	138 (9.5) initial 102 (7.0) final	138 (9.5) initial 88 (6.1) final
Moisture content of paper (%)	9.3	9.3	10.2	6.0	8.2	9.2
First sprinkler operation (min:sec)	0:43	0:32	0:38	0:31	0:28	0:22
Total sprinklers open	88	33	26	64	17	29
Final flow [gpm (L/min)]	2575 (9746)[c]	1992 (7540)	1993 (7544)	4907 (18,573)	1363 (5159)	2156 (8161)
Sprinkler demand area [ft^2 (m^2)]	8800 (817.5)	3300 (306.6)	2600 (241.5)	6400 (595)	1700 (158)	2900 (269)
Average discharge density [gpm/ft^2 (mm/min)]	0.29 (11.8)[c]	0.60 (24.4)	0.77 (31.4)	—	0.92 (37.5) initial 0.80 (32.6) final	0.96 (39.1) initial 0.74 (30.2) final
Maximum 1-minute average gas temperature over ignition [°F (°C)]	1680 (916)[c]	1463 (795)	1634 (890)	1519 (826)	[d]	[e]
Duration of high temperature within acceptable limits	No	Yes	Yes	Marginal	Yes	Yes
Maximum 1-minute average fire plume gas velocity over ignition [ft/sec (m/sec)]	—	40.7 (12.4)	50.2 (15.3)	47.8 (14.6)	—	—
Target ignited	Yes	Yes	No	No	No	Briefly
Extent of fire damage within acceptable limits	No	No	Marginal	Marginal	Yes	Marginal
Test duration (min)	17.4	20	20	25.5	45	45

[a] Phase I test.
[b] Phase III tests decaying pressure.
[c] Pressure increased to 50 psi (3.5 bar) at 10 minutes.
[d] Maximum steel temperature over ignition 341°F (172°C).
[e] Maximum steel temperature over ignition 132°F (56°C).

A.12.6.2.1.4 Generally, more sprinklers open in fires involving roll paper storage protected by sprinklers rated below the high-temperature range. An increase of 67 percent in the design area should be considered.

A.12.7.1 Exposed, expanded plastic donnage, instrument panels, and plastic bumper facia were the automotive components with their related packaging that were utilized in the fire tests. This test commodity used in the large-scale sprinklered fire test proved to be the worst challenge per the large-scale calorimeter tests of available components. See *Technical Report of Fire Testing of Automotive Parts in Portable Storage Racking*, prepared by Underwriters Laboratories, Project 99NK29106, NC4004, January 5, 2001, and *Commodity Hazard Comparison of Expanded Plastic in Portable Bins and Racking*, Project 99NK29106, NC4004, September 8, 2000.

Table A.12.6.2(a) Automatic Sprinkler System Design Criteria — Spray Sprinklers for Existing Storage Facilities (Discharge densities are gpm/ft^2 over ft^2.)

		Heavyweight					Mediumweight			
		Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array
Storage Height (ft)	Clearance (ft)	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded or Unbanded
10	≤5	0.2/2000	0.2/2000	0.2/2000	0.25/2000	0.25/2000	0.2/2000	0.25/2000	0.3/2000	0.3/2000
10	>5	0.2/2000	0.2/2000	0.2/2000	0.25/2500	0.25/2500	0.2/2000	0.25/2000	0.3/2000	0.3/2000
15	≤5	0.25/2000	0.25/2000	0.25/2500	0.3/2500	0.3/3000	0.25/2000	0.3/2000	0.45/2500	0.45/2500
15	>5	0.25/2000	0.25/2000	0.25/2500	0.3/3000	0.3/3500	0.25/2000	0.3/2500	0.45/3000	0.45/3000
20	≤5	0.3/2000	0.3/2000	0.3/2500	0.45/3000	0.45/3500	0.3/2000	0.45/2500	0.6/2500	0.6/2500
20	>5	0.3/2000	0.3/2500	0.3/3000	0.45/3500	0.45/4000	0.3/2500	0.45/3000	0.6/3000	0.6/3000
25	≤5	0.45/2500	0.45/3000	0.45/3500	0.6/2500	0.6/3000	0.45/3000	0.6/3000	0.75/2500	0.75/2500
25	>5	0.45/3000	0.45/3500	0.45/4000	0.6/3000	0.6/3500	0.45/3500	0.6/3500	0.75/3000	0.75/3000
30	≤5	0.6/2500	0.6/3000	0.6/3000	0.75/2500	0.75/3000	0.6/4000	0.75/3000	0.75/3500	0.75/3500

Note: Densities or areas, or both, can be interpolated between any 5-ft storage height increment.

Table A.12.6.2(b) Automatic Sprinkler System Design Criteria — Spray Sprinklers for Existing Storage Facilities (Discharge densities are mm/min over m^2.)

		Heavyweight					Mediumweight			
		Closed Array	Standard Array		Open Array		Closed Array	Standard Array		Open Array
Storage Height (m)	Clearance (m)	Banded or Unbanded	Banded	Unbanded	Banded	Unbanded	Banded or Unbanded	Banded	Unbanded	Banded or Unbanded
3.1	≤1.5	0.76/185.8	0.76/185.8	0.76/185.8	0.95/185.8	0.95/185.8	0.76/185.8	0.95/185.8	12.2/185.8	12.2/185.8
3.1	>1.5	0.76/185.8	0.76/185.8	0.76/185.8	0.95/232.3	0.95/232.3	0.76/185.8	0.95/185.8	12.2/185.8	12.2/185.8
4.6	≤1.5	0.95/185.8	0.95/185.8	0.95/232.3	12.2/232.3	12.2/278.7	0.95/185.8	12.2/185.8	18.3/232.3	18.3/232.3
4.6	>1.5	0.95/185.8	0.95/185.8	0.95/232.3	12.2/278.7	12.2/325.2	0.95/185.8	12.2/232.3	18.3/278.7	18.3/278.7
6.1	≤1.5	12.2/185.8	12.2/185.8	12.2/232.3	18.3/278.7	18.3/325.2	12.2/185.8	18.3/232.3	24.5/232.3	24.5/232.3
6.1	>1.5	12.2/185.8	12.2/232.3	12.2/278.7	18.3/325.2	18.3/371.6	12.2/232.3	18.3/278.7	24.5/278.7	24.5/278.7
7.6	≤1.5	18.3/232.3	18.3/278.7	18.3/325.2	24.5/232.3	24.5/278.7	18.3/278.7	24.5/278.7	30.6/232.3	30.6/232.3
7.6	>1.5	183/278.7	18.3/325.2	18.3/371.6	24.5/278.7	24.5/325.2	18.3/325.2	24.5/325.2	30.6/278.7	30.6/278.7
9.1	≤1.5	24.5/232.3	24.5/278.7	24.5/278.7	30.6/232.3	30.6/278.7	24.5/371.6	30.6/278.7	30.6/325.2	30.6/325.2

Note: Densities or areas, or both, can be interpolated between any 1.5-m storage height increment.

A.12.7.2 These special designs are based on fire heat release calorimeter tests and 10 full-scale tests conducted by the Retail Fire Research Coalition at Underwriters Laboratories in 2000. *[See Figure A.12.7.2(a) through Figure A.12.7.2(f).]*

A.13.4.1.1 Spray application operations should only be located in buildings that are completely protected by an approved system of automatic sprinklers. If located in unsprinklered buildings, sprinklers should be installed to protect spray application processes where practical. Because of the rapidity and intensity of fires that involve spray operations, the available water should be ample to simultaneously supply all sprinklers likely to open in one fire without depleting the available water for use by hose streams. Noncombustible draft curtains can be used to limit the number of sprinklers that will open.

Even when areas adjacent to coating operations are considered under reasonably positive fire control by adequate automatic sprinkler protection, damage is possible if operations are conducted on floors above those containing contents that are highly susceptible to water damage. Waterproofing and drainage of spray room floors can assist in reducing water damage on floors below. The proper drainage of the large volume of water frequently necessary to extinguish spray finishing room fires often presents considerable difficulty. [**33:** A.7.2]

A.13.4.2.1 Automatic sprinklers in spray areas, including the interior of spray booths and exhaust ducts, should be wet pipe, preaction, or deluge system in order that water can be placed on the fire in the shortest possible time. Automatic sprinklers in spray booths and exhaust ducts should be of the lowest practical temperature rating. Sprinklers outside the booth at ceiling level should be high temperature–rated [286°F (141°C)]. The delay in application of water with ordinary dry pipe sprinklers can permit a fire to spread so rapidly that final extinguishment is difficult without large resulting damage.

The location of the sprinklers inside spray booths should be selected with care in order to avoid sprinklers being placed in the direct path of spray and yet afford protection for the entire booth interior. When in the direct path of spray even one day's operation can result in deposits on the sprinkler head that insulate the fusible link or choke open head orifices to the extent that sprinklers cannot operate efficiently.

Automatic sprinklers should also be located so that areas subject to substantial accumulations of overspray residue are protected. Generally, sprinklers are located no more than 4 ft (1.2 m) from side walls of booths and rooms and from dry overspray collectors (where applicable). Sprinklers in booths

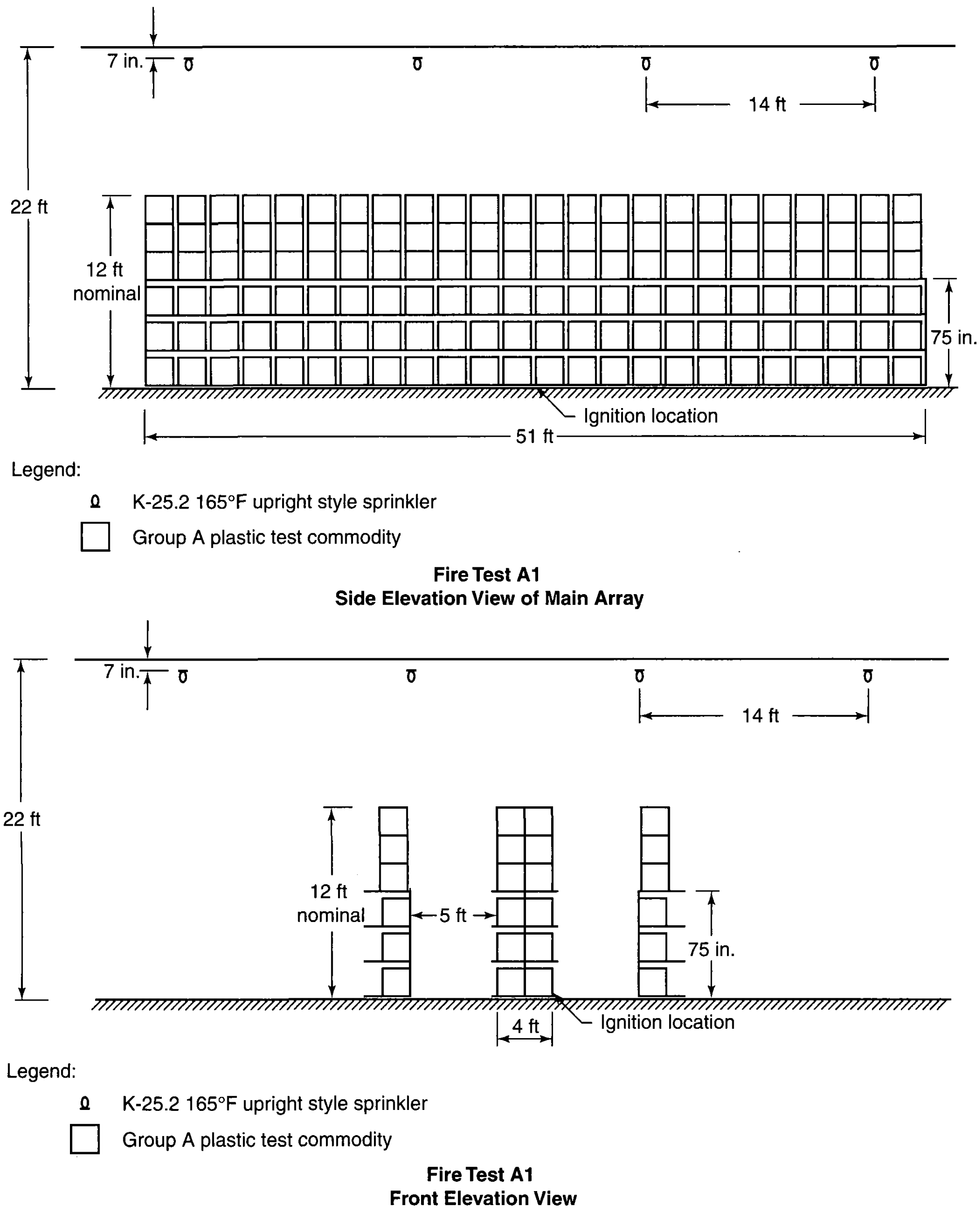


FIGURE A.12.7.2(a) Fire Test A1.

or rooms should be on extra hazard occupancy spacing of 90 ft^2 (9.4 m^2).

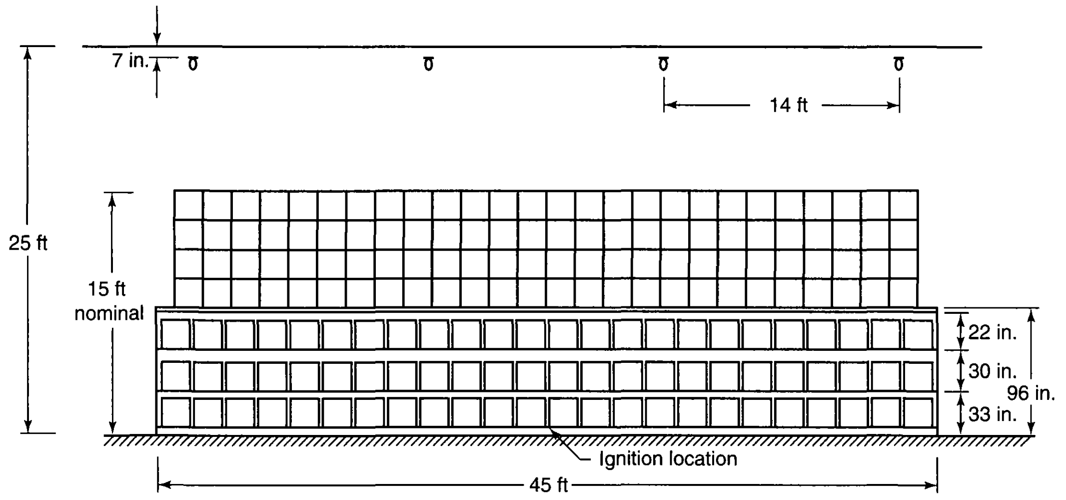
Sprinklers or sprinkler systems protecting stacks or ducts should be automatic and of a type not subject to freezing. Dry pendent sprinklers are often used inside buildings near exhaust duct penetrations to the outside. Nonfreeze or dry type sprinkler systems are often used for ducts outside buildings. Sprinklers should be spaced no more than 12 ft (3.7 m) apart in the duct for adequate protection.

All sprinklers in spray areas should be controlled by an accessible control valve, preferably an OS&Y valve. [**33:** A.7.2.4]

A.13.5.1 Water spray or deluge systems that are used to protect solvent extraction process equipment or structures should be designed to provide a density of not less than 0.25 gpm/ft^2 (10.2 L/min·m^2) of protected surface area. *(See NFPA 13 and NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection, for additional information.)* Foam-water sprinkler or deluge systems that are used for the same purposes should be designed to provide a density of not less than 0.16 gpm/ft^2 (6.5 L/min·m^2) of protected surface area. *(See NFPA 13 and NFPA 16, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems, for additional information.)*

Preparation buildings should be protected with automatic sprinkler systems designed for Ordinary Hazard (Group 2), in accordance with NFPA 13. [**36:** A.2.9]

A.13.6.2.3.3 The arrangement of sprinklers or nozzles for providing distribution over the face of shelving is important and requires knowledge of sprinkler discharge patterns and locations. This arrangement should be done only by qualified personnel. [**40:**4.3.6.3]

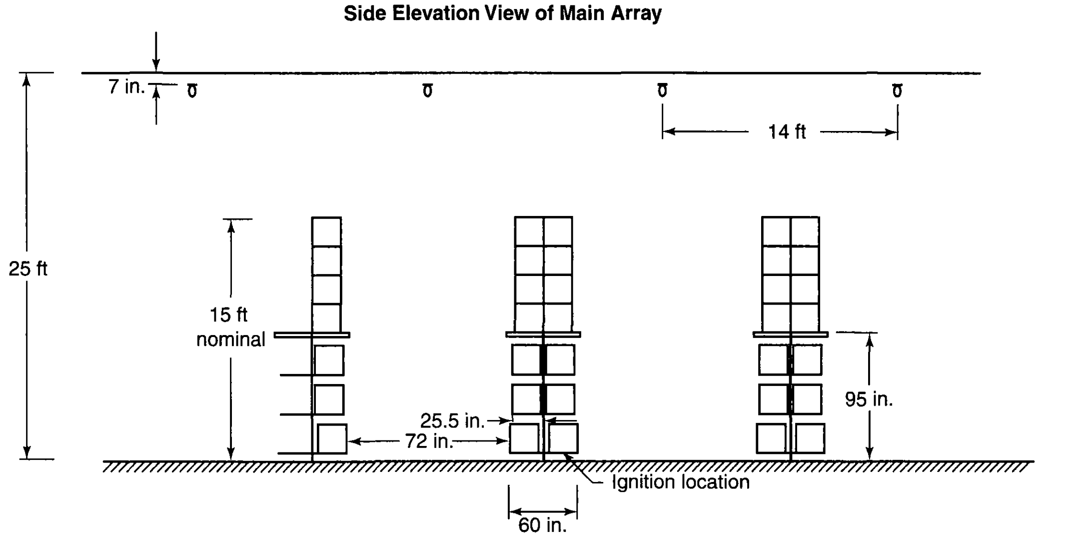


Legend:

K-25.2 165°F upright style sprinkler

Group A plastic test commodity

Fire Test A2
Side Elevation View of Main Array



Legend:

K-25.2 165°F upright style sprinkler

Group A plastic test commodity

Fire Test A2
Front Elevation View

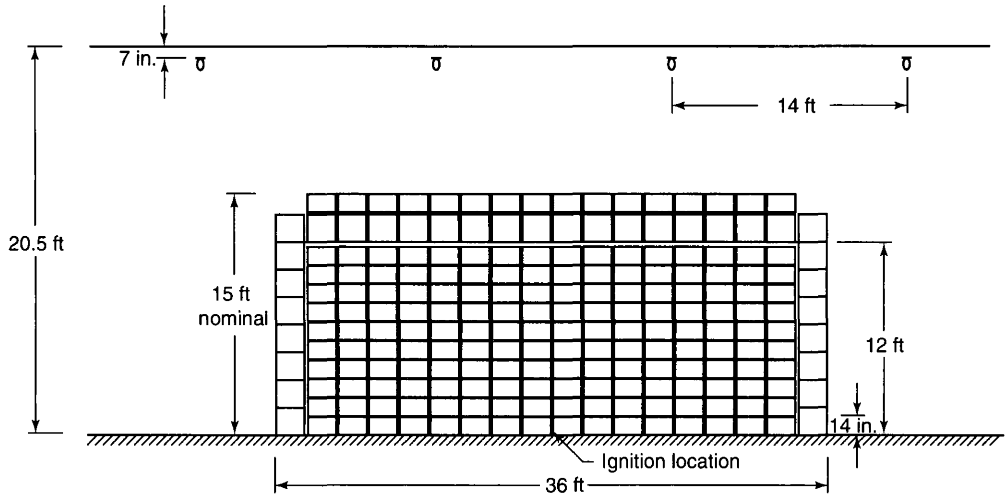
FIGURE A.12.7.2(b) Fire Test A2.

A.13.18.1.2 More than one control station could be required in a compartment (lock) depending on its size. [**99:** A.19.2.5.2.1]

A.13.18.1.4 Experience has shown that when water is discharged through conventional sprinklers into a hyperbaric atmosphere, the spray angle is reduced because of increased resistance to water droplet movement in the denser atmosphere. This is so even though the water pressure differential is maintained above chamber pressure. Therefore, it is necessary to compensate by increasing the number of sprinklers. It is recommended that spray coverage tests be conducted at maximum chamber pressure.

Some chamber configurations, such as small-diameter horizontal cylinders, might have a very tiny "floor," or even no floor at all. For horizontal cylinder chambers and spherical chambers, "floor level" shall be taken to mean the level at ¼ diameter below the chamber centerline or actual "floor level," whichever gives the larger floor area. [**99:** A.19.2.5.2.3]

A.13.18.1.5 Experience has shown that when water is discharged through conventional sprinklers into a hyperbaric atmosphere, the spray angle is reduced because of increased resistance to water droplet movement in the denser atmosphere. This is so even though the water pressure differential



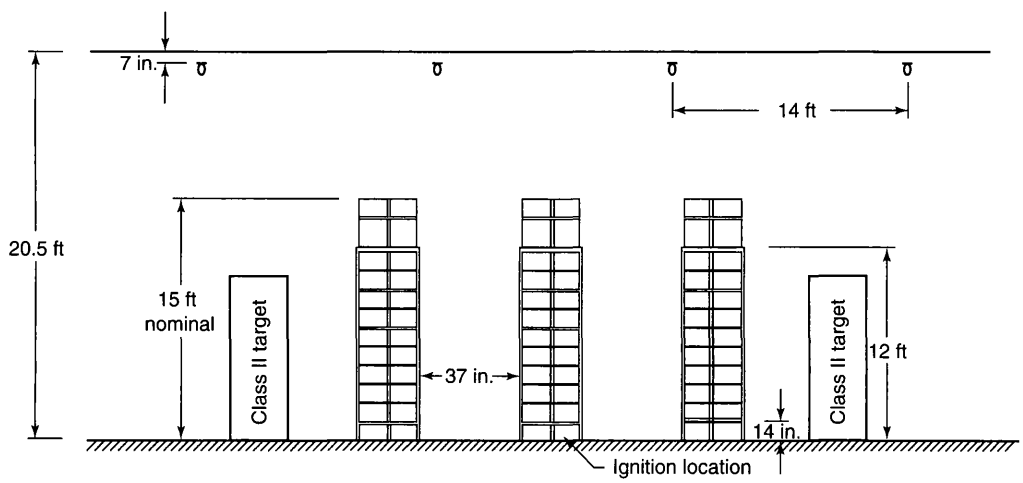
Legend:

K-25.2 165°F upright style sprinkler

Group A plastic test commodity nominal 12.25 in. tall

Group A plastic test commodity nominal 21 in. tall

Fire Test A3
Side Elevation View of Main Array



Legend:

K-25 165°F QR upright style sprinkler

Group A plastic test commodity nominal 12.25 in. tall

Group A plastic test commodity nominal 21 in. tall

Fire Test A3
Front Elevation View

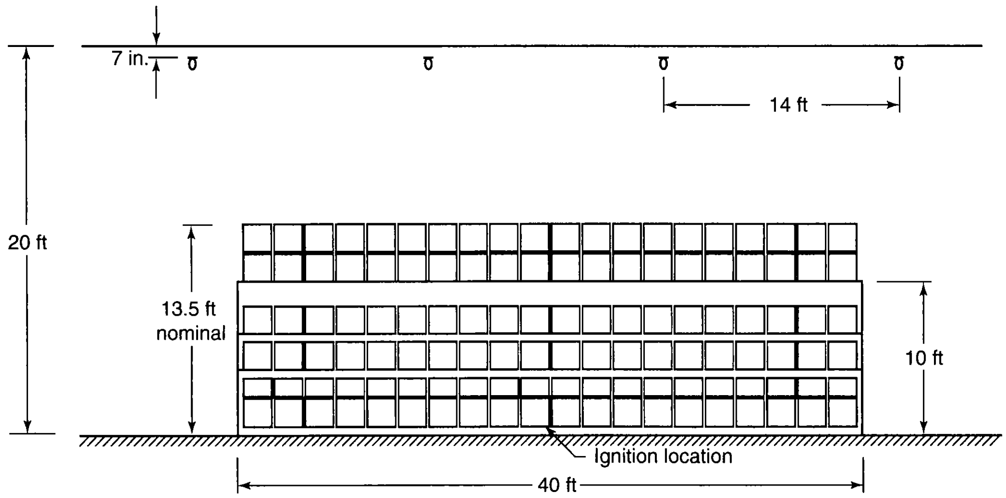
FIGURE A.12.7.2(c) Fire Test A3.

is maintained above chamber pressure. Therefore, it is necessary to compensate by increasing the number of sprinklers. It is recommended that spray coverage tests be conducted at maximum chamber pressure.

Some chamber configurations, such as small-diameter horizontal cylinders, could have a very tiny "floor," or even no floor at all. For horizontal cylinder chambers and spherical chambers, "floor level" should be taken to mean the level at ¼ diameter below the chamber centerline or actual "floor level," *whichever gives the larger floor area.* [**99:** A.19.2.5.2.3]

A.13.21.1.1.1 A deluge system provides a higher degree of protection where water supplies are adequate. In climates that are subject to freezing temperatures, a deluge system minimizes the possibility of failure due to pipes freezing. [**214:** A.3.2.2.1]

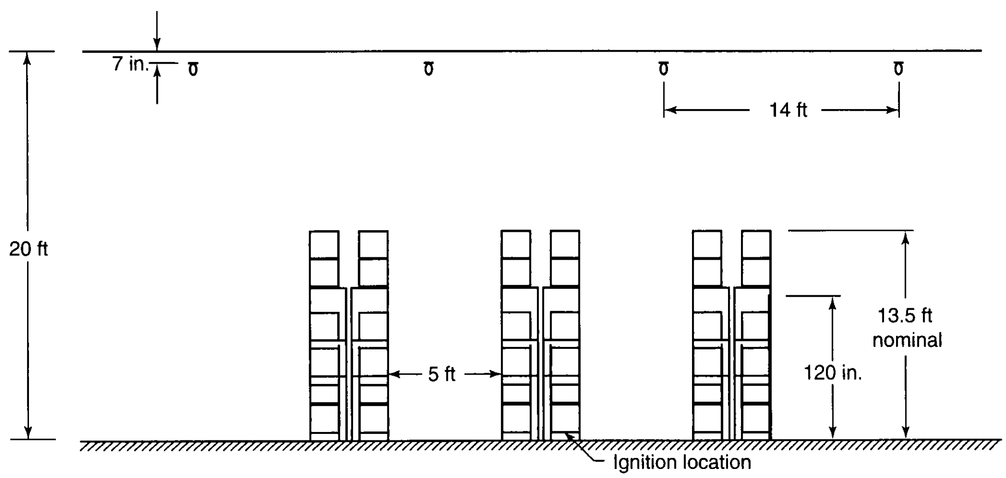
A.13.21.1.1.2 The crossflow design is such that it is difficult to locate sprinklers in the most desirable spots for both water distribution and heat detection. This situation can be solved by separating these two functions and using separate water discharge and detection systems. [**214:** A.3.2.2.2]



Legend:

- K-25.2 165°F upright style sprinkler
- Group A plastic test commodity nominal 12.25 in. tall
- Group A plastic test commodity nominal 21 in. tall

Fire Test A4
Side Elevation View of Main Array

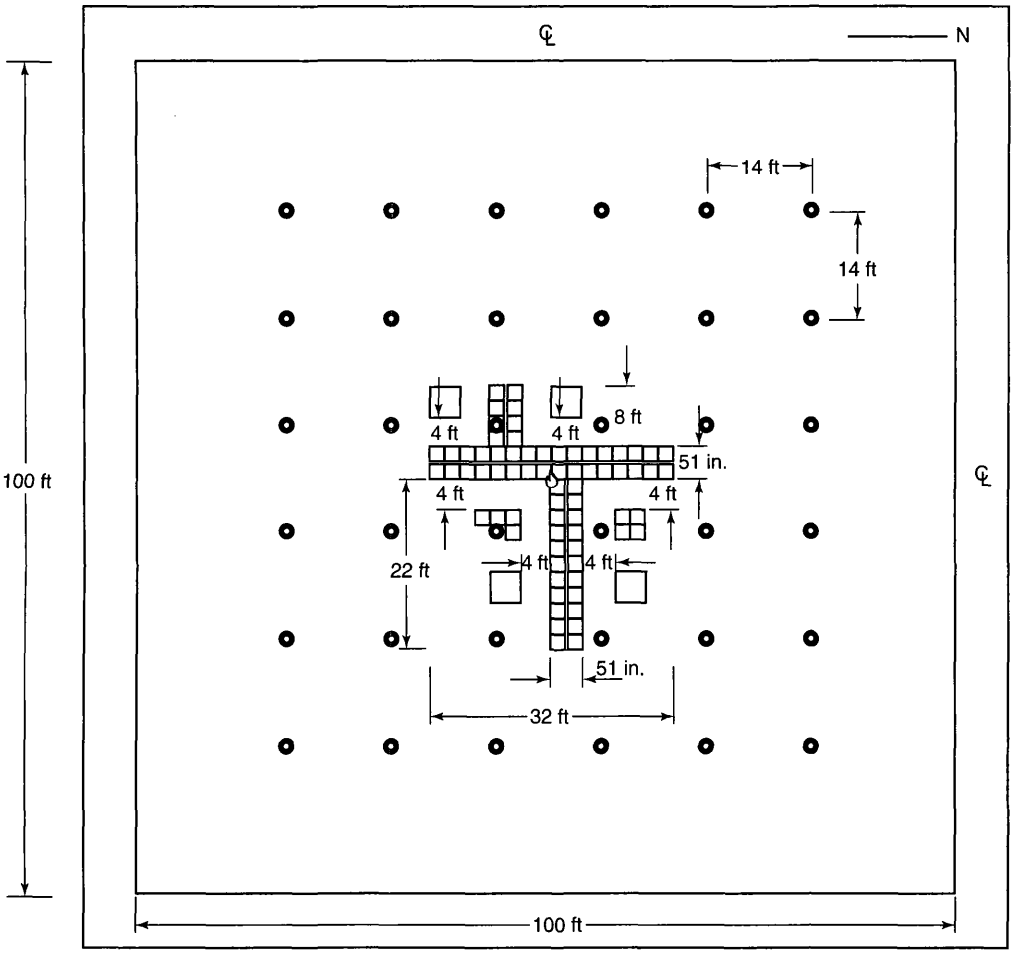


Legend:

- K-25.2 165°F upright style sprinkler
- Group A plastic test commodity nominal 12.25 in. tall
- Group A plastic test commodity nominal 21 in. tall

Fire Test A4
Front Elevation View

FIGURE A.12.7.2(d) Fire Test A4.



Shelving suspended on wire uprights at 24 in., 48 in., 72 in., 96 in., and 120 in. with a wire shelf at 148 in.

Legend:

- K-25 upright style sprinkler 165°F QR, 0.55 gpm/ft² water density for first four sprinkler operations, then 0.49 gpm/ft² for all additional operations
- Group A plastic test commodity
- Class II target commodity
- Ignition location

Fire Test A6
Plan View

FIGURE A.12.7.2(e) Fire Test A6 — Plan View.

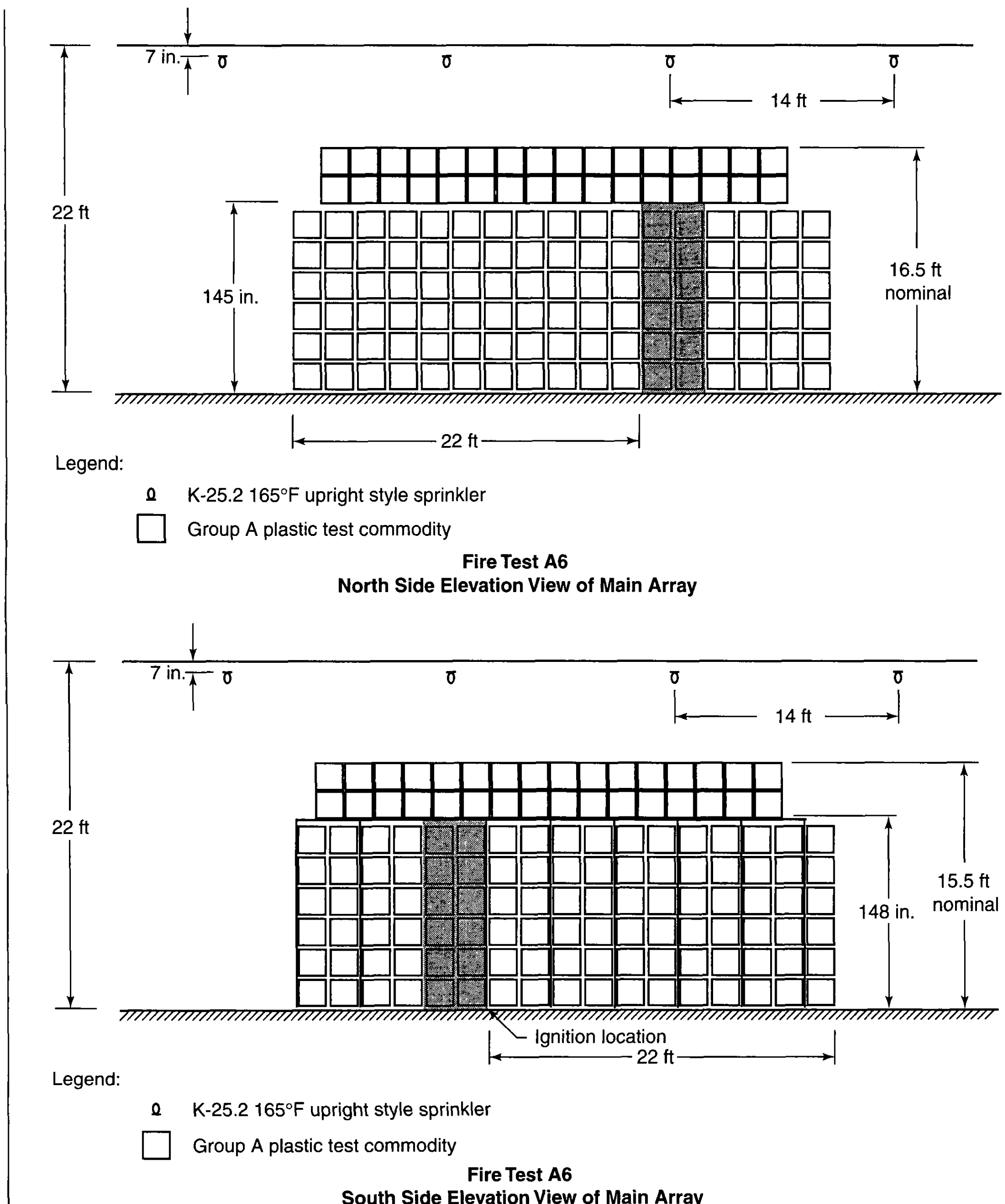


FIGURE A.12.7.2(f) Fire Test A6 — Main Array (North/South).

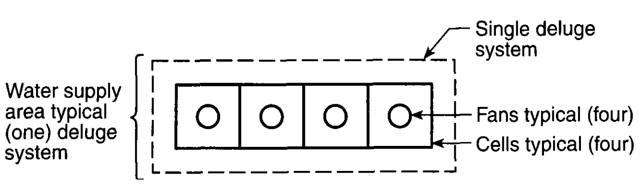


FIGURE A.13.21.1.7.1.1 Single Deluge System. [214: Figure A.3.6.1.1]

A.13.21.1.7.1.1 Where a single deluge system protects an entire water-cooling tower, regardless of the number of cells, the water supply needs to be based on the entire deluge system coverage. Refer to Figure A.13.21.1.7.1.1. [**214:** A.3.6.1.1]

A.13.21.1.7.1.3 Deluge systems separated by fire-resistant partitions can be treated independently as worst-case water supply situations. Refer to Figure A.13.21.1.7.1.3. [**214:** A.3.6.1.3]

A.13.21.1.7.2.1 Water-cooling towers with each cell separated by a fire-resistant partition and protected by wet, dry, or preaction system(s) should have the water supply based on the most demanding individual cell. Refer to Figure A.13.21.1.7.2.1. [**214:** A.3.6.2.1]

A.13.21.1.7.2.2 Without fire-resistant partitions between cells, the worst-case situation involves the most demanding adjoining cells. Refer to Figure A.13.21.1.7.2.2. [**214:** A.3.6.2.2]

A.13.21.2.1 See Figure A.13.21.2.1(a) through Figure A.13.21.2.1(d).

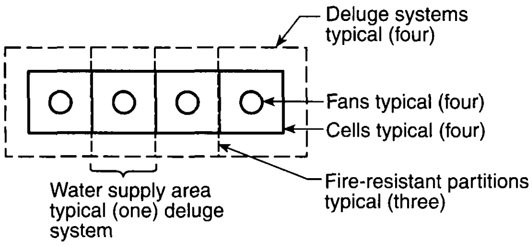


FIGURE A.13.21.1.7.1.3 Multiple Deluge Systems. [214: Figure A.3.6.1.3]

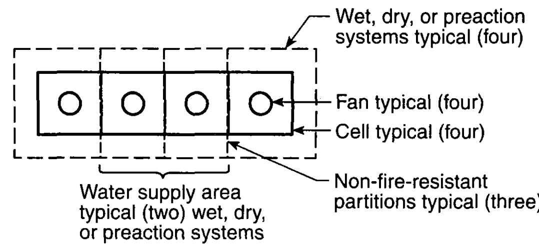


FIGURE A.13.21.1.7.2.2 Multiple Wet, Dry, or Preaction Systems with No Fire-Resistant Partitions. [214: Figure A.3.6.2.2]

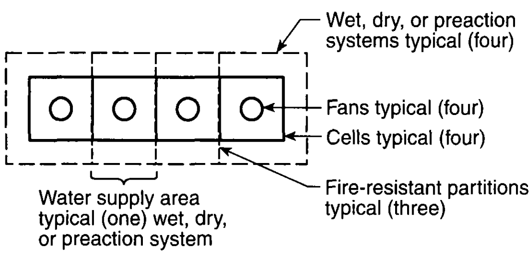


FIGURE A.13.21.1.7.2.1 Multiple Wet, Dry, or Preaction Systems with Fire-Resistant Partitions. [214: Figure A.3.6.2.1]

A.13.21.2.2 See Figure A.13.21.2.2(a) through Figure A.13.21.2.2(d).

A.13.21.2.3 Location of the nozzle relative to surfaces to be protected should be determined by the particular nozzle's discharge characteristics. Care should also be taken in the selection of nozzles to obtain waterways not easily obstructed by debris, sediment, sand, and so forth, in the water. *[See Figure A.13.21.2.3(a) and Figure A.13.21.2.3(b).]*

A.13.21.2.5 See Figure A.13.21.2.5.

A.13.21.2.10.2 Approved sprinklers are made of nonferrous material and are corrosion resistant to normal atmospheres. Some atmospheres require special coatings on the discharge devices.

A.13.21.2.10.3 Otherwise, corrosion will attack the exposed metal and will, in time, creep under the wax coating.

A.13.22.1.1 The use of firestops for draft control to bank heat, facilitate the opening of sprinklers, and prevent the overtaxing of the sprinkler system is particularly important in the design of sprinkler protection for combustible substructures. The fire walls and firestops of 3.3.3.6 of NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves*, should be incorporated into the sprinkler system design for this purpose to the maximum extent practical; however, due to limitations in the size of the design area for the sprinkler system, additional firestops will normally be needed. These additional or supplemental firestops need only have limited fire resistance but should be as deep as possible and be of substantial construction, such as double 3-in. (76.2-mm) planking where exposed to the elements. Where not exposed

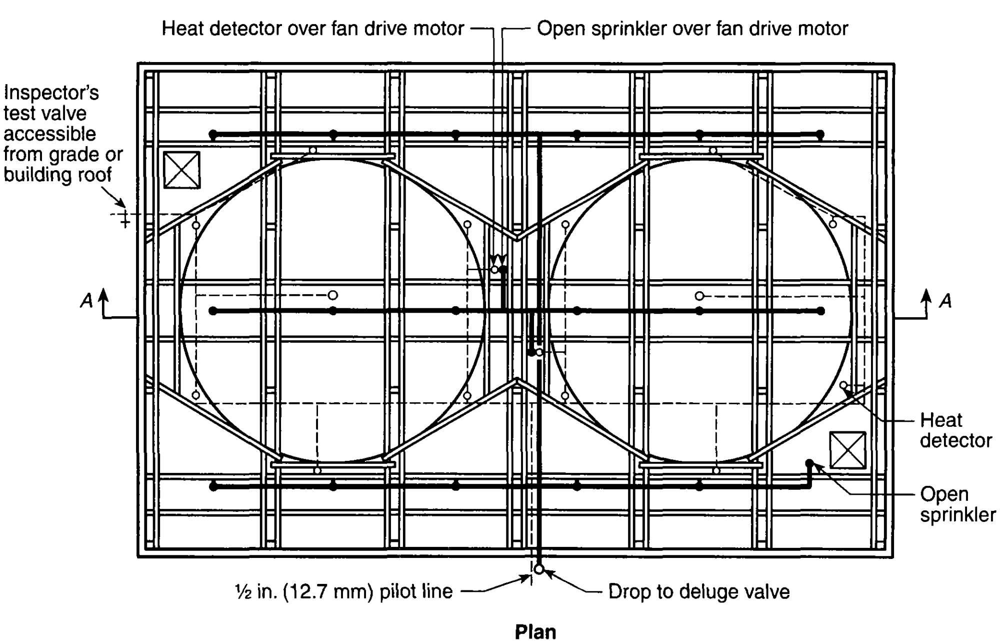


FIGURE A.13.21.2.1(a) Typical Deluge Fire Protection Arrangement for Counterflow Towers, Illustration 1. [214: Figure A.3.2.4.1(a)]

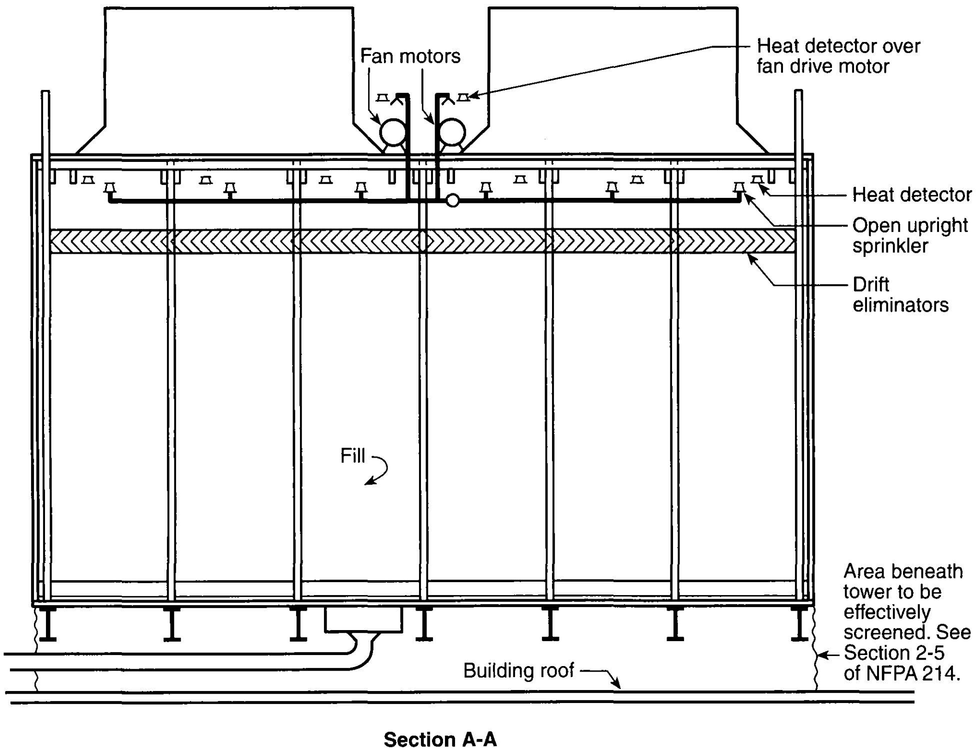


FIGURE A.13.21.2.1(b) Typical Deluge Fire Protection Arrangement for Counterflow Towers, Illustration 2. [214: Figure A.3.2.4.1(b)]

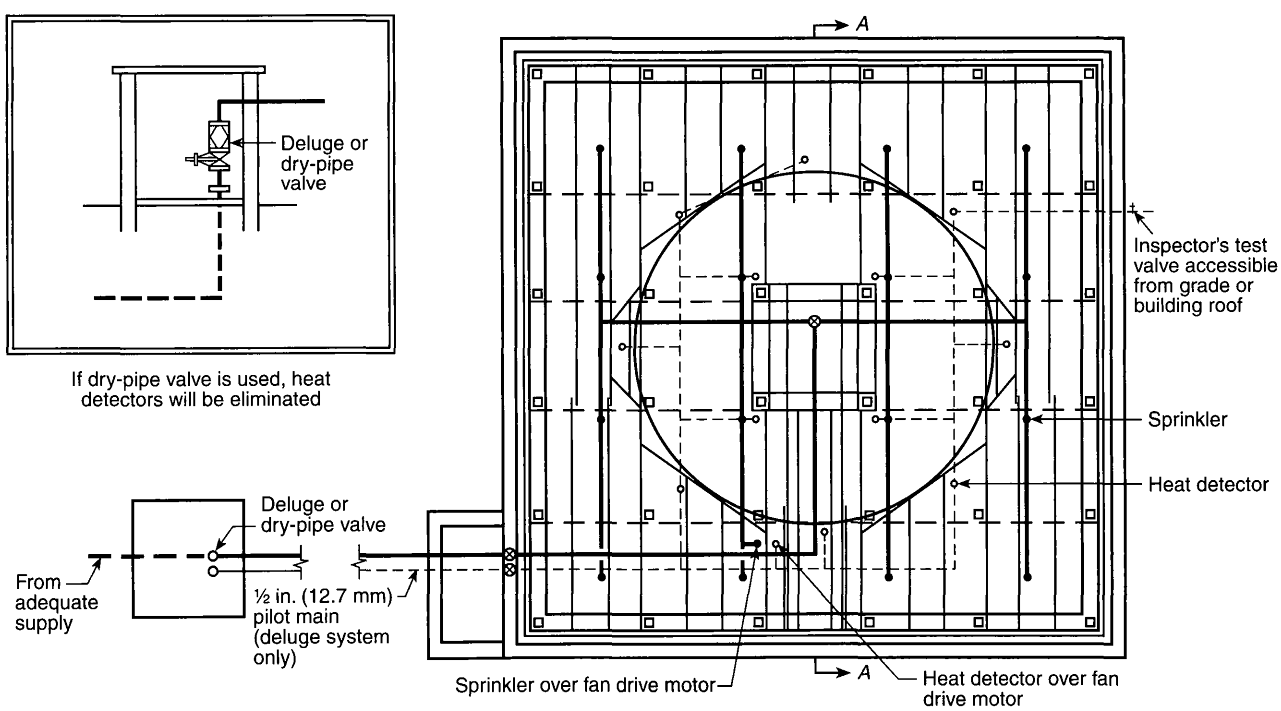


FIGURE A.13.21.2.1(c) Typical Deluge or Dry Pipe Fire Protection Arrangement for Counterflow Towers, Illustration 1. [214: Figure A.3.2.4.1(c)]

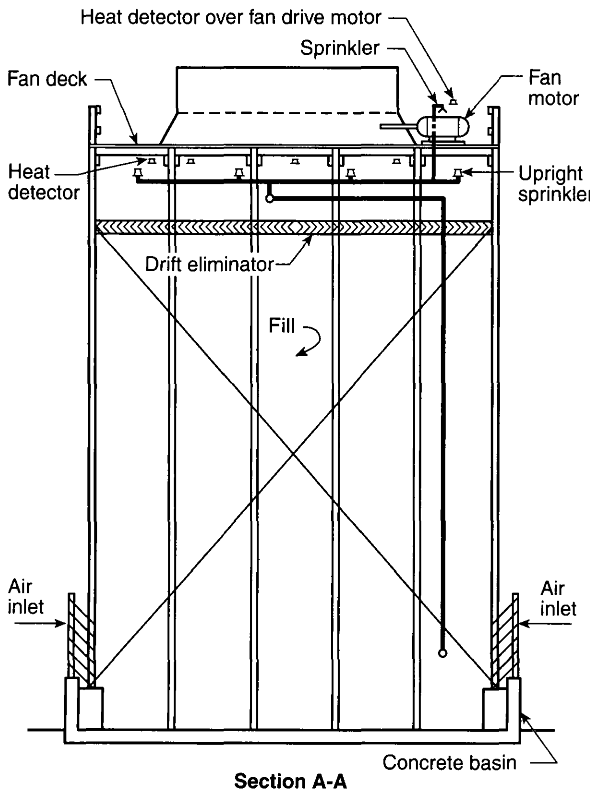


FIGURE A.13.21.2.1(d) Typical Deluge or Dry Pipe Fire Protection Arrangement for Counterflow Towers, Illustration 2. [214: Figure A.3.2.4.1(d)]

to physical damage, ¾-in. (19.05-mm) treated plywood extending 48 in. (1219.2 mm) below stringers with solid blocking between stringers should provide adequate durability and reasonable effectiveness. [**307:** A.3.3.3.3(a)(5)]

A.13.23.1.1 Typical configurations of cleanrooms and their chases and plenums create numerous areas that might be sheltered from sprinkler protection. These areas can include air-mixing boxes, catwalks, hoods, protruding lighting, open waffle slabs, equipment, piping, ducting, and cable trays. Care should be taken to relocate or supplement sprinkler protection to ensure that sprinkler discharge covers all parts of the occupancy. Care should also be taken to ensure that sprinklers are located where heat will be satisfactorily collected for reliable operation of the sprinkler.

Gaseous fire suppression systems are not substitutes for automatic sprinkler protection. The large number of air changes in cleanrooms can cause dilution or stratification of the gaseous agent.

It is recommended that sprinkler systems be inspected at least semiannually by a qualified inspection service *(see NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems).* The length of time between such inspections can be decreased due to ambient atmosphere, water supply, or local requirements of the authority having jurisdiction.

Prior to taking a sprinkler system out of service, one should be certain to receive permission from all authorities having jurisdiction and notify all personnel who might be affected during system shutdown. A fire watch during maintenance periods is a recommended precaution. Any sprinkler system taken out of service for any reason should be returned to service as promptly as possible.

A sprinkler system that has been activated should be thoroughly inspected for damage and components replaced or repaired promptly. Sprinklers that did not operate but were subjected to corrosive elements of combustion or elevated temperatures should be inspected, and replaced if necessary, in accordance with the minimum replacement requirements of the authority having jurisdiction. Such sprinklers should be destroyed to prevent their reuse. [**318:** A.2.1.2.1]

A.13.23.1.3 Small-orifice sprinklers, ⅜ in. (9.5 mm) or larger, can be used. [**318:** A.2.1.2.1.6.1]

A.13.23.2.2 The use of quick-response sprinklers, while still delayed in opening by the downward airflow, would respond to a smaller size fire quicker than conventional sprinklers. (Glass bulb-type quick response sprinklers might be preferable to other types of quick-response sprinklers.) [**318:** A.2.1.2.2]

A.13.23.2.3 Small orifice sprinklers, 3/8 in. (9.5 mm) or larger, can be used. [**318:** A.2.1.2.6.1]

A.13.25.1.2 The exposure to the airport terminal building from the airport ramp is significant. The number of building sprinklers operating from the exposure fire can be greater than from an internal ignition source. [**415:** A.2.5.1.2]

A.13.26.1.1 Because of the nature of the test cell fire potential, deluge systems are considered more appropriate than automatic sprinklers due to their speed of operation and simultaneous discharge of all nozzles; however, automatic sprinklers can be used under the following conditions.

(1) In small cells [600 ft^2 (56 m^2) or less] where it is likely that all sprinklers would fuse at the same time
(2) As a backup to a manual water spray or other manual system

[**423:** A.5.6.3]

A.13.27.1.4.1 For the purposes of Table 13.27.1.4.1, the fire hazard potential of Class 2 oxidizers has been considered as approximately equal to Group A plastic (non-expanded), stable cartoned. [**430:** A.4.4.1]

A.13.27.1.5.1 For the purposes of Table 13.27.1.5.1, the sprinkler density has been derived from fire loss history. [**430:** A.5.4.1]

A.13.27.2 At the time of the publication of this standard, the Technical Committee on Sprinkler System Installation Criteria is aware of ongoing research concerning the sprinkler protection of solid oxidizers. This research is being conducted by the National Fire Protection Research Foundation.

A.13.29.1.1 The water supply for the permanent fire protection water system should be based on providing a 2-hour water supply for both items (1) and (2) as follows:

(1) Either of the following items, a or b, whichever is larger:
   (a) The largest fixed fire suppression system demand
   (b) Any fixed fire suppression system demand that could be reasonably expected to operate simultaneously during a single event (e.g., turbine underfloor protection in conjunction with other fire protection systems in the turbine area)
(2) The hose stream demand of not less than 500 gpm (1892.5 L/min).

[**804:** A.7.2.1]

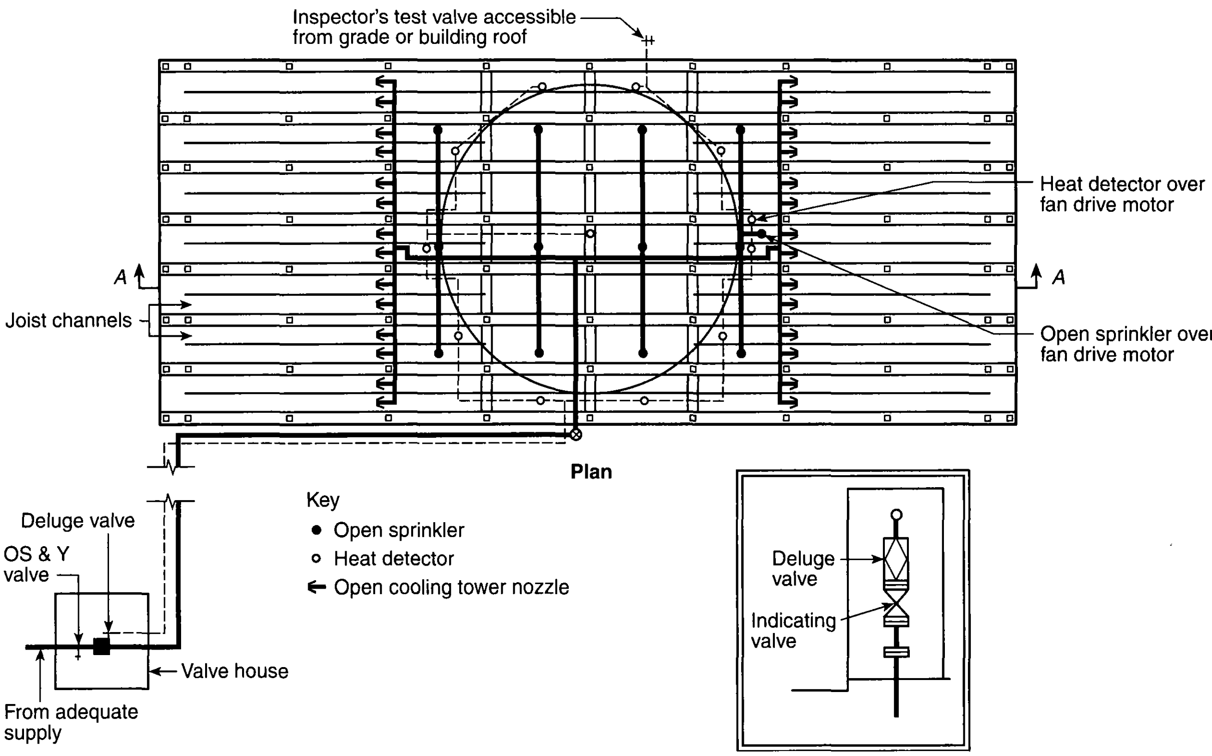


FIGURE A.13.21.2.2(a) Typical Deluge Fire Protection Arrangement for Crossflow Towers, Illustration 1. [214: Figure A.3.2.4.2(a)]

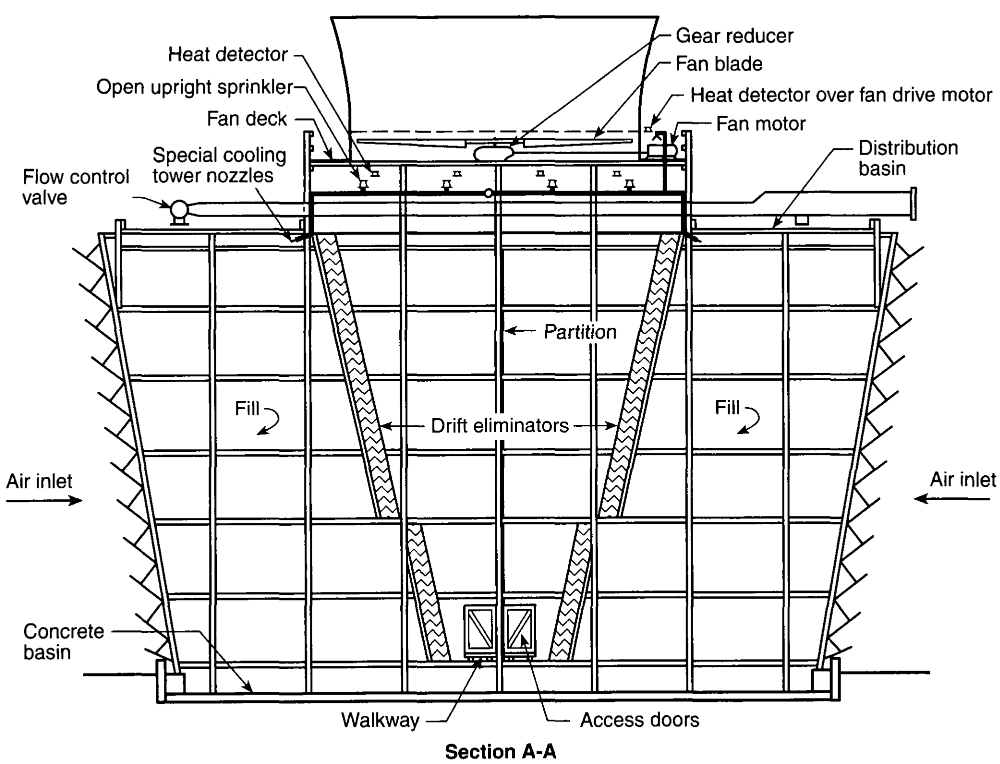
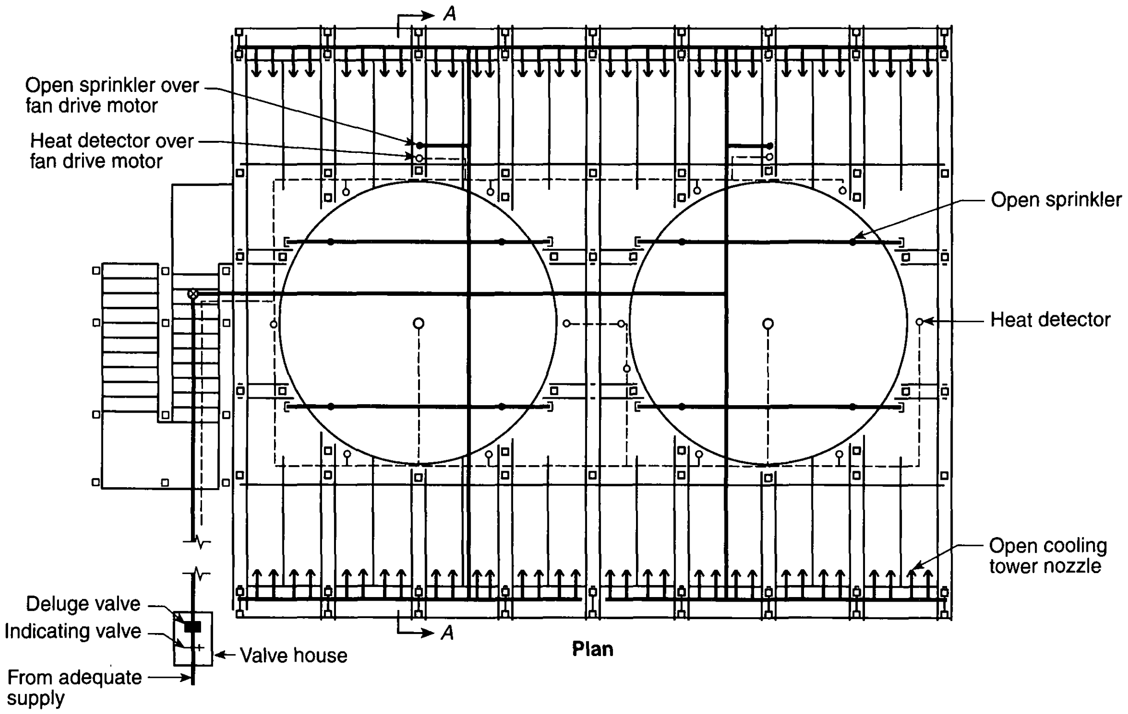
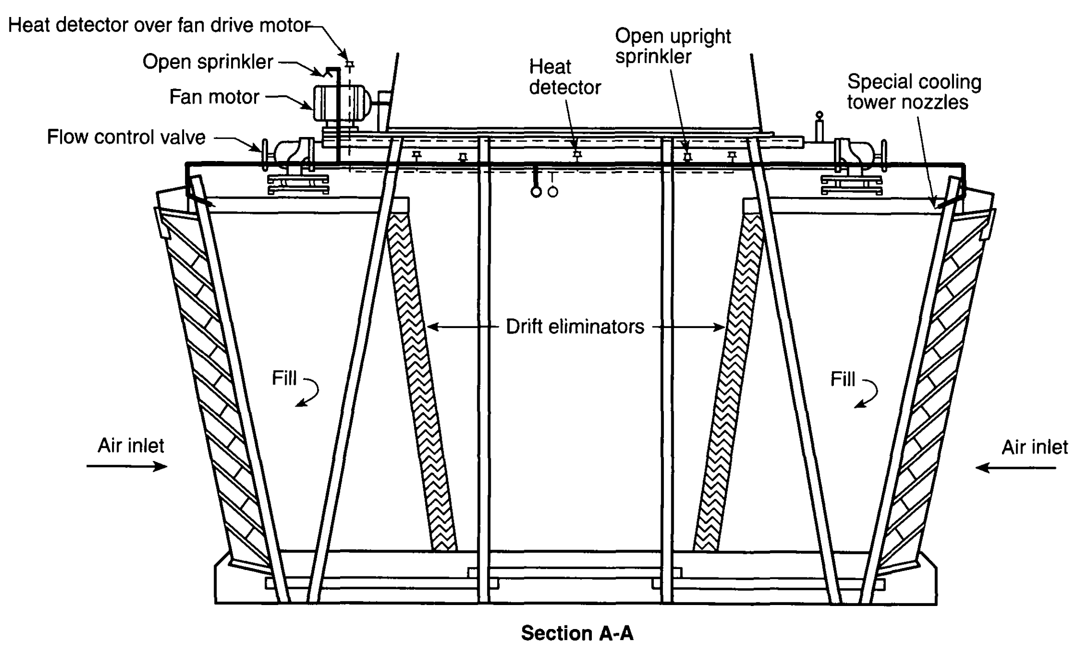


FIGURE A.13.21.2.2(b) Typical Deluge Fire Protection Arrangement for Crossflow Towers, Illustration 2. [214: Figure A.3.2.4.2(b)]



Note: Where air seal boards prevent installation of cooling tower nozzles on drift eliminator side of fill, this nozzle location should be used.

FIGURE A.13.21.2.2(c) Typical Deluge Fire Protection Arrangement for Crossflow Towers, Illustration 3. [214: Figure A.3.2.4.2(c)]



Note: Where air seal boards prevent installation of cooling tower nozzles on drift eliminator side of fill, this nozzle location should be used.

FIGURE A.13.21.2.2(d) Typical Deluge Fire Protection Arrangement for Crossflow Towers, Illustration 4. [214: Figure A.3.2.3.2(d)]

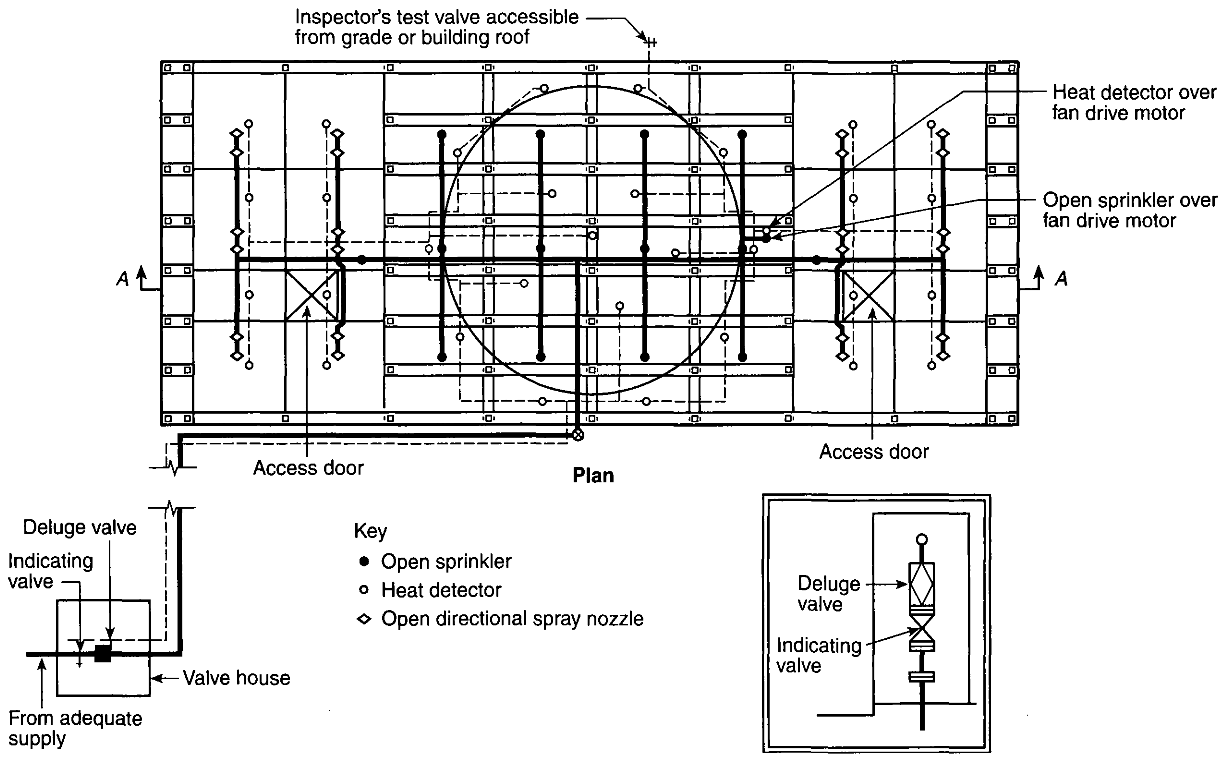


FIGURE A.13.21.2.3(a) Typical Deluge Fire Protection Arrangement for Crossflow Towers with Completely Enclosed Distribution Basins, Illustration 1. [214: Figure A.3.2.4.3(a)]

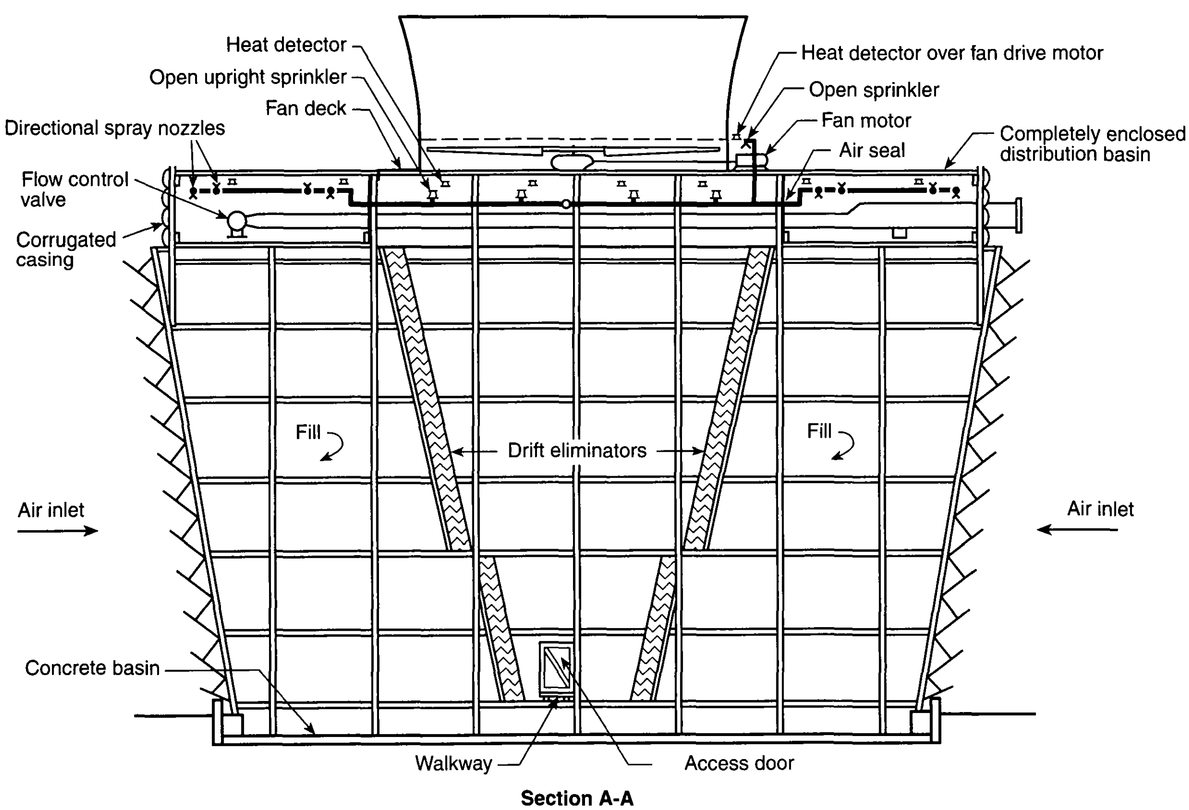


FIGURE A.13.21.2.3(b) Typical Deluge Fire Protection Arrangement for Crossflow Towers with Completely Enclosed Distribution Basins, Illustration 2. [214: Figure A.3.2.4.3(b)]

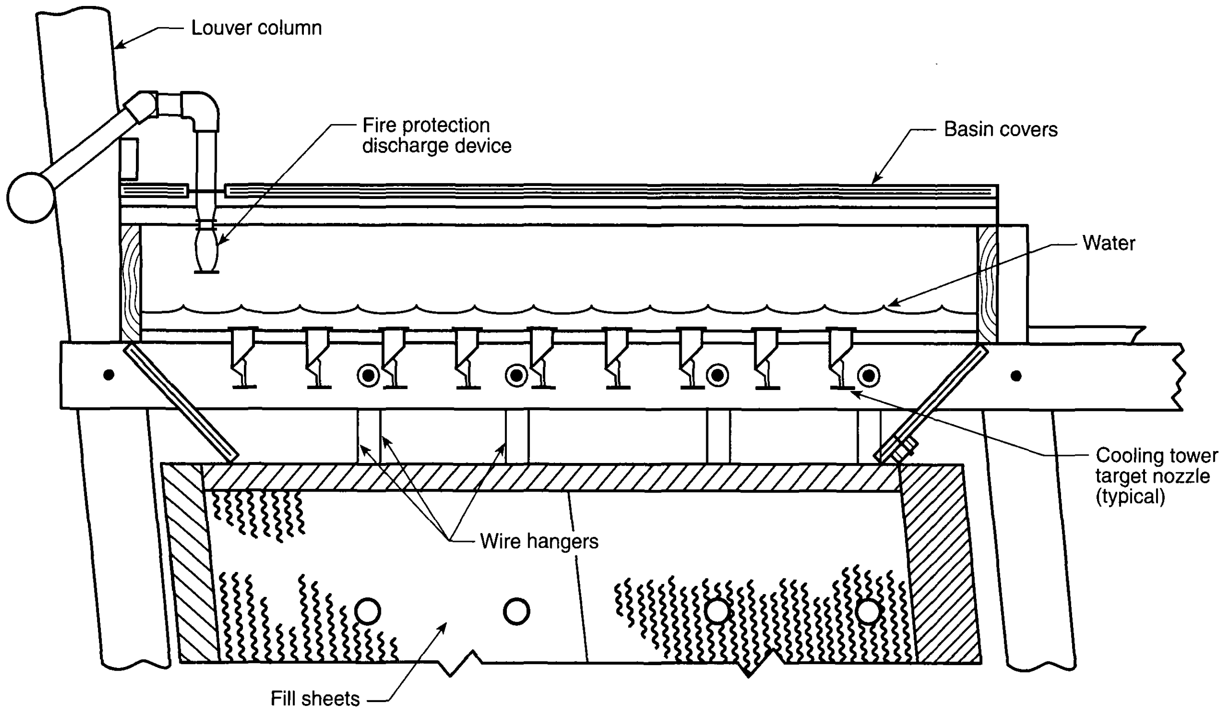


FIGURE A.13.21.2.5 Typical Deluge Fire Protection Arrangement for Crossflow Towers with Covers Completely Enclosing Distribution Basins. [214: Figure A.3.2.4.5]

A.13.29.1.5 To avoid water application to hot parts or other water-sensitive areas and to provide adequate coverage, designs that incorporate items such as fusible element operated spray nozzles might be necessary. [**804:** A.8.8.2.1]

A.13.29.1.6 Additional information concerning turbine generator fire protection can be found in EPRI Research Report 1843-2, "Turbine Generator Fire Protection by Sprinkler System," July 1985. [**804:** A.8.8.3]

A.13.29.2.1.2 A common yard fire main loop can serve multi-unit nuclear power plant sites if it is cross-connected between units.

A.13.30.1 Cement-lined pipe 12 in. (304.8 mm) in diameter is recommended. Main sizes should be designed to encompass any anticipated expansion.

The underground main should be arranged such that any one break will not put both a fixed water extinguishing system and hose lines protecting the same area out of service. [**805:** A.3.5.1]

A.13.31.1 Sprinkler System Discharge Criteria for Electric Generating Plants and High-Voltage Direct Current Converter Stations. See NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*, for applicable terms not defined in Chapter 3.

(1) *Sprinkler System Water Supply.* The water supply for the permanent fire protection installation should be based on providing a 2-hour supply for both items (a) and (b) as follows:
   (a) Either of items i or ii below, whichever is larger:
      i. The largest fixed fire suppression system demand
      ii. Any fixed fire suppression system demands that could reasonably be expected to operate simultaneously during a single event [e.g., turbine underfloor protection in conjunction with other fire protection system(s) in the turbine area; coal conveyor protection in conjunction with protection for related coal handling structures during a conveyor fire; adjacent transformers not adequately separated according to 3.1.3 of NFPA 850].
   (b) The hose stream demand of not less than 500 gpm (31.5 L/sec).
   [**850:**4.2.1]
   Where an adequate and reliable water supply, such as a lake, cooling pond, river, or municipal water system, is unavailable, at least two separate water supplies should be provided for fire protection purposes with each supply capable of meeting the fire waterflow requirements determined by 4.2.1 of NFPA 850. [**850:**4.2.2]
(2) *Yard Mains.* The supply mains should be looped around the main power block and should be of sufficient size to supply the flow requirements determined by 4.2.1 of NFPA 850 to any point in the yard loop considering the most direct path to be out of service. Pipe sizes should be designed to encompass any anticipated expansion and future water demands. [**850:**4.4.1.3]
(3) *Coal Handling Structures.* Sprinkler systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) density over a 2500 ft^2 (232 m^2) area. [**850:**5.4.6.1]

(4) *Coal Conveyors.* Sprinklers should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) density over 2000 ft^2 (186 m^2) of enclosed area or the most remote 100 linear ft (30 m) of conveyor structure up to 2000 ft^2 (186 m^2). [**850:** 5.4.6.2]

(5) [In areas over conveyor belts and striker plates within the stacker reclaimer,] the water supply [should] be from a 3000-gal to 5000-gal (11,355-L to 18,925-L) capacity pressure tank located on-board. [**850:**5.4.6.4]

(6) Sprinklers for bag-type dust collectors should be designed for ordinary hazard systems. Sprinkler systems should be designed for a density of 0.2 gpm (8.2 mm/min) over the projected plan area of the dust collector. [**850:**5.4.6.5.1]

(7) *Steam Generator.* Boiler front fire protection systems should be designed to cover the fuel oil burners and ignitors, adjacent fuel oil piping and cable, a 20 ft (6.1 m) distance from the burner and ignitor including structural members and walkways at these levels. Additional coverage should include areas where oil may collect. Sprinkler and water spray systems should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the protected area. [**850:**5.5.1.2]

(8) *Flue Gas Bag-Type Dust Collectors.* The design density should be 0.2 gpm/ft^2 (8.2 mm/min) over the plan area of the dust collector. [**850:**5.6.3.3]

(9) *Electrostatic Precipitators.* If mineral oil insulating fluids are used, hydrants or standpipes should be located so that each transformer-rectifier set can be reached by at least one hose stream. In addition the following should be provided:
Automatic sprinkler protection. Automatic sprinkler systems should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over 3500 ft^2 (325 m^2). The drain system should be capable of handling oil spillage plus the largest design waterflow from the fire protection system. [**850:** 5.6.4.3]

(10) *Scrubber Buildings.* Where scrubbers have plastic or rubber linings, one of the following methods of protection for the building should be provided:
Automatic sprinkler protection at ceiling level sized to provide a density 0.2 gpm/ft^2 (8.2 mm/min). The area of operation should be the area of the building or 10,000 ft^2 (930 m^2). Where draft curtains are provided the area of operation can be reduced to the largest area subdivided by draft curtains. [**850:**5.6.5.2.2]

(11) *Turbine-Generator Area.* The sprinkler system beneath the turbine-generator should take into consideration obstructions from structural members and piping and should be designed to a density of 0.3 gpm/ft^2 (12.2 mm/min) over a minimum application of 5000 ft^2 (464 m^2).
NOTE: To avoid water application to hot parts or other water sensitive areas and to provide adequate coverage, designs that incorporate items such as fusible element operated directional spray nozzles may be necessary. [**850:**5.7.4.1, 5.7.4.1.1]
The automatic sprinkler system [protecting the lubricating oil lines above the turbine operating floor] should be designed to a density of 0.3 gpm/ft^2 (12.2 mm/min). [**850:**5.7.4.1.2]

(12) *Turbine-Generator Bearings.* Fire protection systems for turbine-generator bearings should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the protected area. [**850:**5.7.4.2.1]

(13) *Cable Spreading Room and Cable Tunnels.* Automatic sprinkler systems should be designed for a density of 0.3 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (232 m^2) or the most remote 100 linear ft (30 m) of cable tunnels up to 2500 ft^2 (232 m^2). [**850:**5.8.2.1]

(14) *Emergency Generators.* Sprinkler systems should be designed for a 0.25 gpm/ft^2 (10.2 mm/min) density over the fire area. [**850:**5.9.1.2.1]

(15) *Fire Pumps.* If sprinkler systems are provided for fire pump houses, they should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the fire area. [**850:**5.9.4]

(16) *Oil- or Coal-Fueled Auxiliary Boilers.* If a sprinkler system is provided it should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the entire room.

(17) *Alternative Fuels.*

(a) *Hydraulic Equipment, Reservoirs, Coolers, and Associated Oil-Filled Equipment.* Sprinklers should be over oil-containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft^2 (10.2 mm/min) should be provided. [**850:**7.3.4.3]

(b) *Tipping/Receiving Building.* Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used.
NOTE: The above requirements are based on storage heights not exceeding 20 ft (6.1 m). [**850:**7.3.4.4]

(c) *The MSW Storage Pit, Charging Floor, and Grapple Laydown Areas.* Systems should be designed for a minimum of 0.2 gpm/ft^2 (8.2 mm/min) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of pit/floor area with the protection area per sprinkler not to exceed 100 ft^2 (9.3 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used. [**850:**7.3.4.5.1]

(18) *Refuse Derived Fuels.*

(a) *Hydraulic Equipment, Reservoirs, Coolers, and Associated Oil-Filled Equipment.* Sprinklers should be over oil-containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft^2 (10.2 mm/min) should be provided. [**850:**7.4.4.6]

(b) *Tipping/Receiving Building.* Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used.
NOTE: The above requirements are based on storage heights not exceeding 20 ft (6.1 m). [**850:**7.4.4.7]

(c) *Processing Building.* Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2). [**850:**7.4.4.8)]

(d) *RDF Storage Building.* Systems should be designed for a minimum of 0.35 gpm/ft^2 (14.3 mm/min) over

the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 100 ft^2 (9.3 m^2). High temperature sprinklers [250°F to 300°F (121°C to 149°C)] should be used. Storage heights in excess of 20 ft (6.1 m) will require higher design densities. [**850:**7.4.4.9]

(e) *RDF Boiler Feed System Area, Including Bins, Hoppers, Chutes, Conveyors, and So Forth.* Where provided, the systems should be designed for a minimum of 0.2 gpm/ft^2 (8.2 mm/min) over the most remote 2000 ft^2 (186 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2). Internal, as well as external, protection also should be considered depending upon specific equipment design, ceiling heights, and accessibility for manual fire fighting. [**850:**7.4.4.10]

(f) *Shredder Enclosures.* Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 100 ft^2 (9.3 m^2). [**850:**7.4.4.11]

(19) *Biomass Fuels.*

(a) *Biomass Storage Buildings.* Systems should be designed for a minimum of 0.25 gpm/ft^2 (10.2 mm/min) over the most remote 3000 ft^2 (279 m^2) (increase by 30 percent for dry pipe systems) of floor area with the protection area per sprinkler not to exceed 130 ft^2 (12.0 m^2).

NOTE: Biomass fuels exhibit a wide range of burning characteristics and upon evaluation can require increased levels of protection.

[**850:**7.5.4.4]

(b) *Hydraulic Equipment, Reservoirs, Coolers, and Associated Oil-Filled Equipment.* Sprinklers or spray nozzles should be over oil-containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft^2 (10.2 mm/min) should be provided. [**850:**7.5.4.6]

(20) *Rubber Tire Fuel — Hydraulic Equipment, Reservoirs, Coolers, and Associated Oil-Filled Equipment.* Sprinklers should be over oil-containing equipment and for 20 ft (6.1 m) beyond in all directions. A density of 0.25 gpm/ft^2 (10.2 mm/min) should be provided. [**850:**7.6, 7.6.4.10]

A.13.31.2 Where an adequate and reliable water supply, such as a lake, cooling pond, river, or municipal water system, is unavailable, at least two separate water supplies should be provided for fire protection purposes with each supply capable of meeting the fire waterflow requirements determined by 4.2.1 of NFPA 850. [**850:**4.2.2]

Each water supply should be connected to the yard main by separate connections arranged and valve controlled to minimize the possibility of multiple supplies being impaired simultaneously. [**850:**4.2.3]

Indicator control valves should be installed to provide adequate sectional control of the fire main loop to minimize plant protection impairments. [**850:**4.4.1.4)]

Each hydrant should be equipped with a separate shutoff valve located on the branch connection to the supply main. [**850:**4.4.1.5]

Interior fire protection loops are considered an extension of the yard main and should be provided with at least two valved connections to the yard main with appropriate sectional control valves on the interior loop. [**850:**4.4.1.6]

If a sprinkler system is used to protect the coal conveyor, particular care should be exercised in locating closed sprinkler so that they will be in the path of the heat produced by the fire and still be in a position to provide good coverage of all belt surfaces along the conveyor. [**850:**5.4.6.2.1]

Protection inside dust collectors should include the clean air plenum and the bag section. If the hopper is shielded from water discharge, sprinklers also should be provided in the hopper section.

All areas beneath the turbine-generator operating floor that are subject to oil flow, oil spray, or oil accumulation should be protected by an automatic sprinkler of foam-water sprinkler system. This coverage normally includes all areas beneath the operating floor in the turbine building. [**850:**5.7.4.1.1]

Lubricating oil lines above the turbine operating floor should be protected with an automatic sprinkler system covering those areas subject to oil accumulation including the area within the turbine lagging (skirt). [**850:**5.7.4.1.2]

Turbine-generator bearings should be protected with a manually or automatically operated closed-head sprinkler system utilizing directional nozzles. [**850:**5.7.4.2.1]

Due to the large quantity of platforms, equipment, and walkways, care should be taken to include coverage under all obstructions greater than 4 ft (1.2 m) wide. (**850:** 7.4.4.8)

A.13.32.1 Sprinkler System Discharge Criteria for Hydroelectric Generating Plants. See NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants,* for applicable terms not defined in Chapter 3.

(1) *Sprinkler Systems Water Supply.* The water supply for the permanent fire protection installation should be based on the largest fixed fire suppression system demand plus the maximum hose stream demand of not less than 500 gpm (31.5 L/sec) for a 2-hour duration. [**851:**4.2.2]
(2) If a single water supply is utilized, two independent connections should be provided. If a situation can arise in which the primary water supply can become unavailable (e.g., dewatering of penstocks), an auxiliary supply should be provided. Each supply should be capable of meeting the requirements in 4.2.2 of NFPA 851. [**851:**4.2.3]
(3) Fixed fire protection for this equipment, where provided, should be automatic wet pipe sprinkler systems utilizing a design density of 0.25 gpm/ft^2 (10.2 mm/min) for the entire hazard area *(see 3.5.3 of NFPA 803).* [**851:**5.2.4]
(4) Sprinkler or water spray systems should be designed for a density of 0.3 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (232 m^2). This coverage is for area protection. Individual cable tray tier coverage could be required based on the Fire Risk Evaluation. [**851:**5.5.3]
(5) *Cable Tunnels.* Automatic sprinkler systems should be designed for a density of 0.3 gpm/ft^2 (12.2 mm/min) over 2500 ft^2 (232 m^2) or the most remote 100 linear ft (30 m) of cable tunnel up to 2500 ft^2 (232 m^2). [**851:**5.6.1]
(6) *Emergency Generators.* Sprinkler and water spray protection systems should be designed for a 0.25 gpm/ft^2 (10.2 mm/min) density over the fire area. [**851:**5.11.2]

(7) *Air Compressors.* Automatic sprinkler protection, with a density of 0.25 gpm/ft^2 (10.2 mm/min) over the postulated oil spill, should be considered for air compressors containing a large quantity of oil. *(See 4.8.2 of NFPA 851.)* [**851**:5.12]
(8) *Hydraulic Systems for Gate and Valve Operators.* Automatic sprinkler protection designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the fire area should be considered for hydraulic systems not using a listed fire-resistant fluid. *(See 4.8.2 of NFPA 851.)* [**851**:5.13]
(9) *Fire Pumps.* If sprinkler systems are provided they should be designed for a density of 0.25 gpm/ft^2 (10.2 mm/min) over the fire area. For automatic foam-water sprinkler systems, a density of 0.16 gpm/ft^2 (6.5 mm/min) should be provided. [**851**:5.14]

A.13.32.2 Upstream water is frequently the fire protection water supply. Water for fire suppression should not be taken downstream from any closure device in a penstock, flume, or forebay. [**851**:4.2.6]

Fire extinguishing systems, where installed for lube oil systems employing combustible-type oil, should include protection for the reservoirs, pumps, and all oil lines, especially where unions exist on piping and beneath any shielded area where flowing oil can collect. Facilities not provided with curbs or drains should extend coverage for a distance of 20 ft (6.1 m) from the oil lines, when measured from the outermost oil line. [**851**:5.2.7]

A.13.33.1 Sprinkler systems for specific areas associated with religious facilities should be designed as follows:

(1) All assembly areas, except state — Light Hazard
(2) Stages — Ordinary Hazard (Group 2)
(3) Kitchens — Ordinary Hazard (Group 1)
(4) Storage rooms — Ordinary Hazard (Group 2)
(5) Unused attics/lofts/steeples/concealed spaces — Light Hazard
(6) Schools/day-care centers — Light Hazard
(7) Gift shops — Ordinary Hazard (Group 1)
(8) Special exhibit area — Ordinary Hazard (Group 2)
(9) Libraries — Ordinary Hazard (Group 2)
(10) Offices — Light Hazard

[**909:** A.10.4.2]

A.14.1 Preliminary plans should be submitted for review to the authority having jurisdiction prior to the development of working plans *[see Figure A.14.1(a)]*. The preliminary plans can be part of the construction documents submitted in order to obtain a building permit. However, working drawings in accordance with Section 14.1 should be submitted and approved prior to the installation of system equipment. Preliminary plans should include as much information as is required to provide a clear representation of the hazard to be protected, the system design concept, the proposed water supply configuration, and building construction information pertinent to system layout and detailing.

The Owner's Information Certificate shown as Figure A.14.1(b) should be used to obtain a declaration of the intended use of the occupancy to be protected.

Drawings that accompany the certificate should include the following:

(1) Name of owner and occupant.
(2) Location, including street address.
(3) Point of compass.
(4) Construction and occupancy of each building.
(5) Building height in feet.
(6) Waterflow test information. If a waterflow test of the city main is available, the drawings should indicate the date and time of the test, the name of the party that conducted the test, the location of the hydrants where the flow was taken and where static and residual pressure readings were recorded *(see A.15.2.1)*, the size and configuration of mains supplying the hydrants, the size and number of open hydrant butts flood, and results of the test.
(7) Building features such as combustible concealed spaces, floor openings, areas subject to freezing, and areas from which it is intended to omit sprinkler protection.
(8) Proposed location and approximate size, if a water supply employing pumps or tanks is contemplated.
(9) Name and address of party submitting the preliminary plans.
(10) Tentative location of underground major piping, including mains, risers, overhead mains, and fire department connections.

A.14.1.1 See Figure A.14.1.1. Underground mains should be designed so that the system can be extended with a minimum of expense. Possible future plant expansion should also be considered and the piping designed so that it will not be covered by buildings.

A.14.1.5 See Figure A.14.1.5(a) and Figure A.14.1.5(b).

A.14.3.2 See Figure A.14.3.2(a) through Figure A.14.3.2(d).

A.14.3.3 See Figure A.14.3.3.

A.14.3.3(15) See Figure A.14.3.3(15).

A.14.3.4 See Figure A.14.3.4.

A.14.4.1 When additional sprinkler piping is added to an existing system, the existing piping does not have to be increased in size to compensate for the additional sprinklers, provided the new work is calculated and the calculations include that portion of the existing system that can be required to carry water to the new work. It is not necessary to restrict the water velocity when determining friction losses using the Hazen-Williams formula.

A.14.4.4 See Figure A.14.4.4.

A.14.4.4.1 See Figure A.14.4.4.1(a) and Figure A.14.4.4.1(b).

A.14.4.4.2 See Figure A.14.4.4.2.

A.14.4.4.3.2 See Figure A.14.4.4.3.2.

A.14.4.4.3.4 This subsection assumes a ceiling constructed so as to reasonably ensure that a fire on one side of the ceiling will operate sprinklers on one side only. Where a ceiling is sufficiently open, or of such construction that operation of sprinklers above and below the ceiling can be anticipated, the operation of such additional sprinklers should be considered in the calculations.

A.14.4.4.4 When it is not obvious by comparison that the design selected is the hydraulically most remote, additional calculations should be submitted. The most distant area is not necessarily the hydraulically most remote.

A.14.4.4.6 The use of sprinklers with differing orifice sizes in situations where different protection areas are needed is not considered balancing. An example would be a room that could be protected with sprinklers having different orifice size in closet,

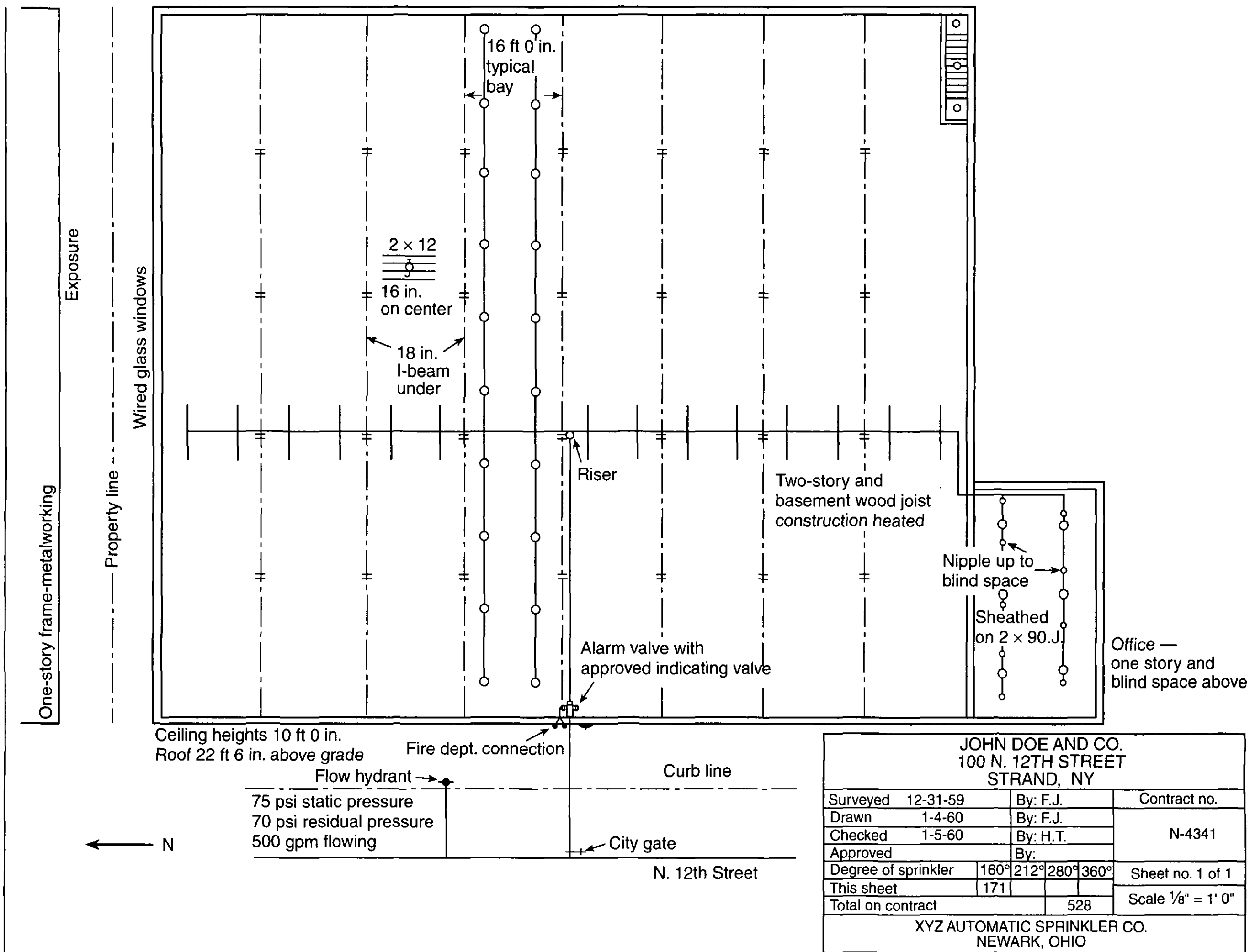


FIGURE A.14.1(a) Typical Preliminary Plan.

foyer, and room areas. However, this procedure introduces difficulties when restoring a system to service after operation since it is not always clear which sprinklers go where.

A.14.4.4.7 Where the normal pressure (P_n) is used to calculate the flow from an orifice, the following assumptions should be used:

(1) At any flowing outlet along a pipe, except the end outlet, only the normal pressure (P_n) can act on the outlet. At the end outlet the total pressure (P_t) can act. The following should be considered end outlets:
   (a) The last flowing sprinkler on a dead-end branch line
   (b) The last flowing branch line on a dead-end cross main
   (c) Any sprinkler where a flow split occurs on a gridded branch line
   (d) Any branch line where a flow split occurs on a looped system
(2) At any flowing outlet along a pipe, except the end outlet, the pressure acting to cause flow from the outlet is equal to the total pressure (P_t) minus the velocity pressure (P_v) on the upstream (supply) side.
(3) To find the normal pressure (P_n) at any flowing outlet, except the end outlet, assume a flow from the outlet in question and determine the velocity pressure (P_v) for the total flow on the upstream side. Because normal pressure (P_n) equals total pressure (P_t) minus velocity pressure (P_v), the value of the normal pressure (P_n) so found should result in an outlet flow approximately equal to the assumed flow; if not, a new value should be assumed, and the calculations should be repeated.

A.14.5.1 The demonstrated effectiveness of pipe schedule systems is limited to their use with ½-in. (13-mm) orifice sprinklers. The use of other size orifices can require hydraulic calculations to prove their ability to deliver the required amount of water within the available water supply.

A.14.5.1.4 Where the construction or conditions introduce unusually long runs of pipe or many angles in risers or feed or cross mains, an increase in pipe size over that called for in the schedules can be required to compensate for increased friction losses.

Owner's Information Certificate

Name/Address of property to be protected with sprinkler protection:

____

____

Name of Owner: ______________________________

Existing or planned construction is:

❑ Fire resistive or noncombustible

❑ Wood frame or ordinary (masonry walls with wood beams)

❑ Unknown

Is the system installation intended for one of the following special occupancies:

Aircraft hangar	❑ Yes	❑ No
Fixed guideway transit system	❑ Yes	❑ No
Race track stable	❑ Yes	❑ No
Marine terminal, pier, or wharf	❑ Yes	❑ No
Airport terminal	❑ Yes	❑ No
Aircraft engine test facility	❑ Yes	❑ No
Power plant	❑ Yes	❑ No
Water-cooling tower	❑ Yes	❑ No

If the answer to any of the above is "yes," the appropriate NFPA standard should be referenced for sprinkler density/area criteria.

Indicate whether any of the following special materials are intended to be present:

Flammable or combustible liquids	❑ Yes	❑ No
Aerosol products	❑ Yes	❑ No
Nitrate film	❑ Yes	❑ No
Pyroxylin plastic	❑ Yes	❑ No
Compressed or liquefied gas cylinders	❑ Yes	❑ No
Liquid or solid oxidizers	❑ Yes	❑ No
Organic peroxide formulations	❑ Yes	❑ No
Idle pallets	❑ Yes	❑ No

If the answer to any of the above is "yes," describe type, location, arrangement, and intended maximum quantities.

____

____

(NFPA 13, 1 of 2)

FIGURE A.14.1(b) Owner's Information Certificate.

A.14.5.2.6 For example, a 2½-in. (64-mm) steel pipe, which is permitted to supply 30 sprinklers, can supply a total of 50 sprinklers where not more than 30 sprinklers are above or below a ceiling.

A.14.5.3.9 For example, a 3-in. (76-mm) steel pipe, which is permitted to supply 40 sprinklers in an ordinary hazard area, can supply a total of 60 sprinklers where not more than 40 sprinklers protect the occupied space below the ceiling.

A.14.5.4 The piping schedule shown in Table A.14.5.4 is reprinted only as a guide for existing systems. New systems for extra hazard occupancies should be hydraulically calculated as required in 14.5.4.

A.14.7 In the design of an exposure protection system, the flow rate from window and cornice sprinklers is shown in Table 14.7. The flow rates are based on the guide numbers selected from Table 4.3.7.3 of NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures.*

Section A of the table is for window sprinklers. The orifice size is selected according to the level on which the sprinkler is located. Section B of the table is for cornice sprinklers.

Indicate whether the protection is intended for one of the following specialized occupancies or areas:

Spray area or mixing room	❑ Yes	❑ No
Solvent extraction	❑ Yes	❑ No
Laboratory using chemicals	❑ Yes	❑ No
Oxygen-fuel gas system for welding or cutting	❑ Yes	❑ No
Acetylene cylinder charging	❑ Yes	❑ No
Production or use of compressed or liquefied gases	❑ Yes	❑ No
Commercial cooking operation	❑ Yes	❑ No
Class A hyperbaric chamber	❑ Yes	❑ No
Cleanroom	❑ Yes	❑ No
Incinerator or waste handling system	❑ Yes	❑ No
Linen handling system	❑ Yes	❑ No
Industrial furnace	❑ Yes	❑ No
Water-cooling tower	❑ Yes	❑ No

If the answer to any of the above is "yes," describe type, location, arrangement, and intended maximum quantities.

Will there be any storage of products over 12 ft (3.6 m) in height?
❑ Yes ❑ No

If the answer is "yes," describe product, intended storage arrangement, and height.

Will there be any storage of plastic, rubber, or similar products over 5 ft (1.5 m) high except as described above?
❑ Yes ❑ No

If the answer is "yes," describe product, intended storage arrangement, and height.

I certify that I have knowledge of the intended use of the property and that the above information is correct.

Signature of owner's representative or agent:

Date:

Name of owner's representative or agent completing certificate (print):

Relationship and firm of agent (print):

(NFPA 13, 2 of 2)

FIGURE A.14.1(b) *Continued*

A.15.1.5 Evaluation of the water supply and environmental conditions does not necessarily require a water sample analysis by a laboratory. Instead, general knowledge of the long-term condition of sprinkler systems with similar piping materials in similar environments on the same water supply can be a sufficient evaluation.

There are several options to address the effects of MIC on sprinkler systems. Some types of sprinkler pipe such as CPVC have not shown to be affected by MIC. Other types of pipe are being manufactured with a biofilm that resists the effects of MIC.

Where water supplies are treated with biocides, evaluation of the effects of the biocide on sprinkler system components (pipe, fittings, sprinklers, gaskets, valves, and seals) is just as important as evaluating the effect the biocide has on the organisms. Where water treatment is selected as the method to deal with MIC, all water entering the system during testing or flushing needs to be treated so that the organisms don't get a chance to establish themselves.

Since all of the conditions that can effect the growth of MIC are unknown, a plan to sample randomly selected interior positions in the system can be effective. The frequency and location of the interior inspections will depend on the extent of the known MIC problem with the same water supply and similar environmental conditions.

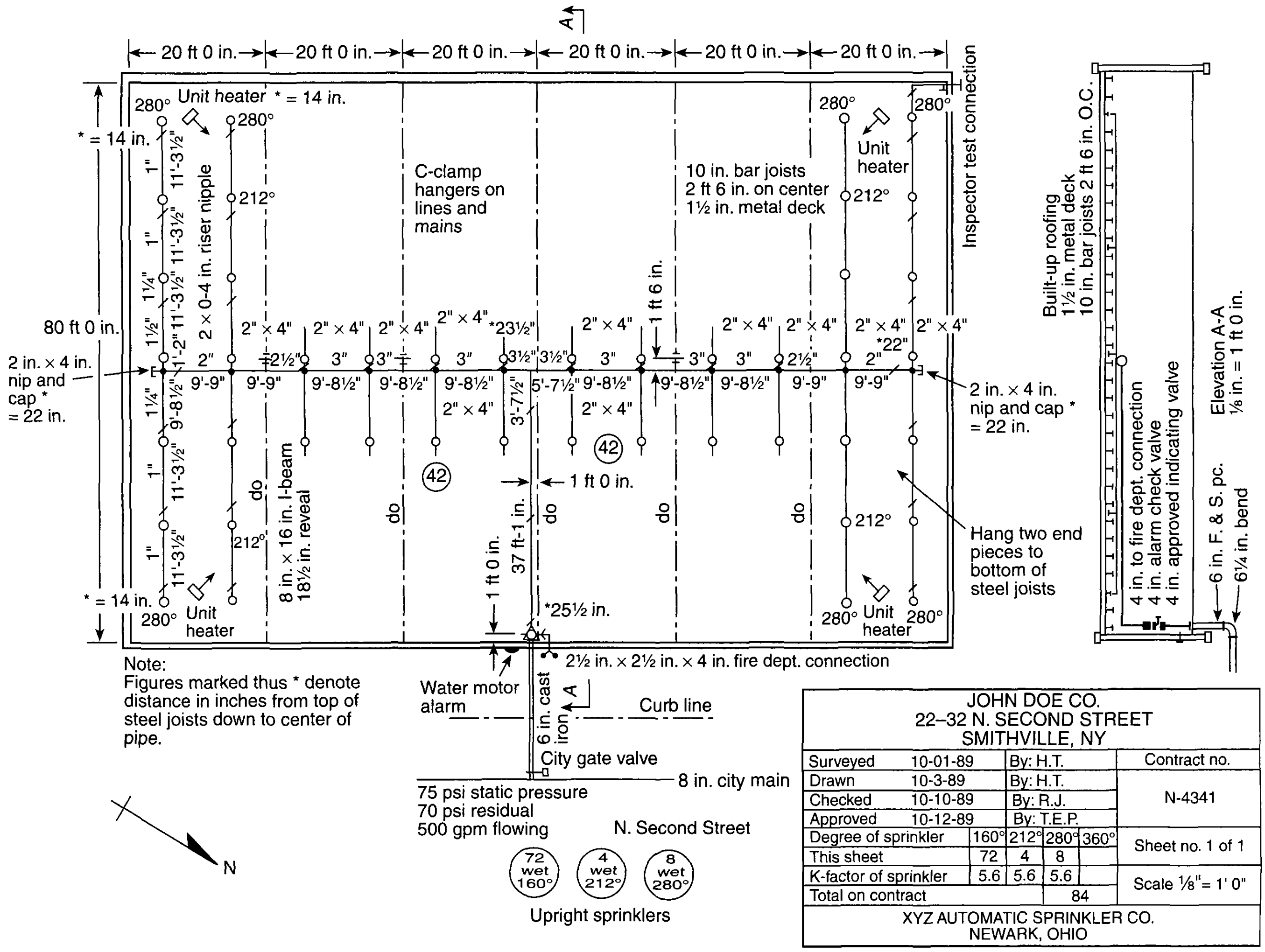


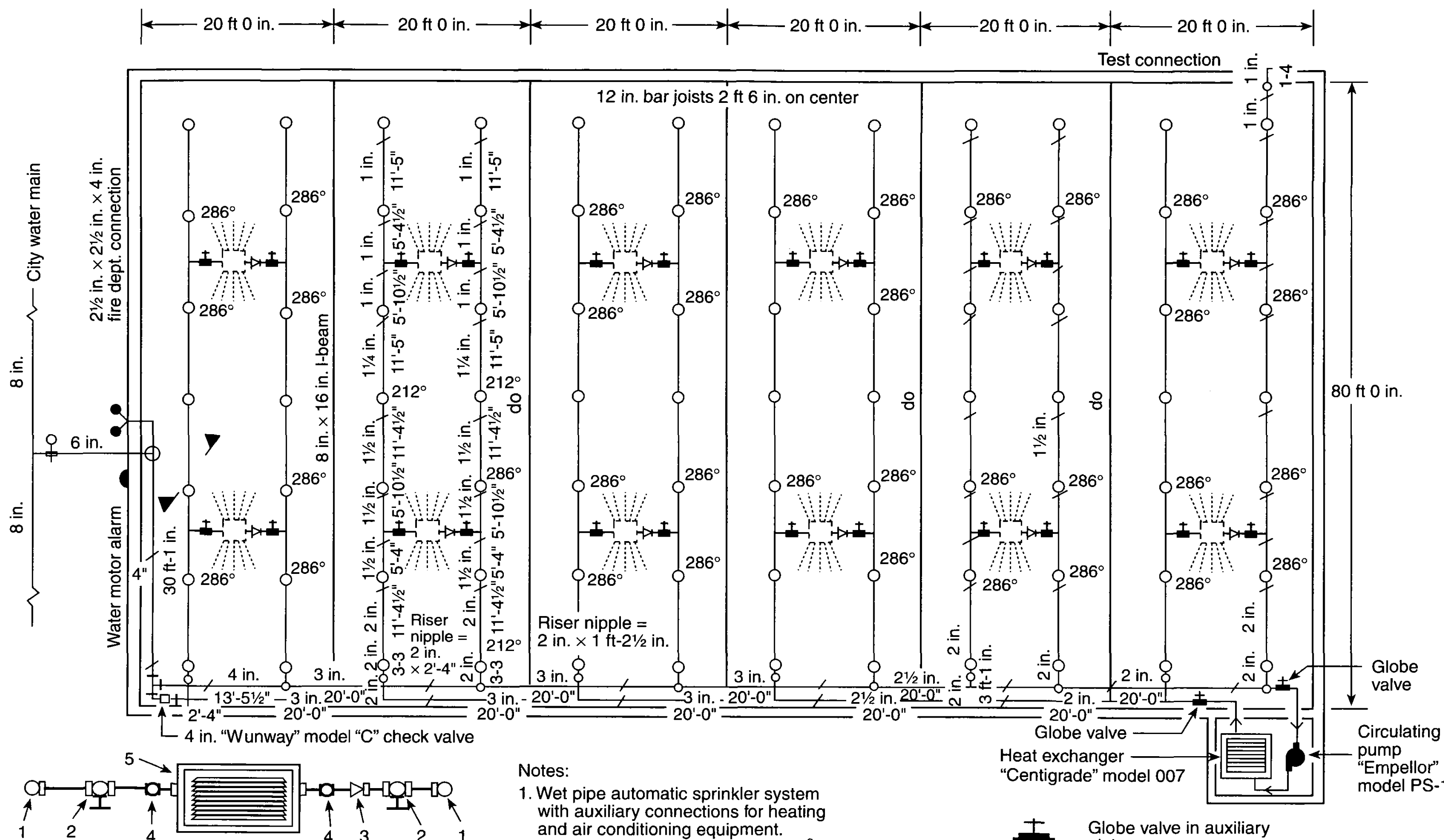
FIGURE A.14.1.1 Typical Working Plans.

A.15.1.6.2 Where the system riser is close to an outside wall, underground fittings of proper length should be used in order to avoid pipe joints located in or under the wall. Where the connection passes through the foundation wall below grade, a 1-in. to 3-in. (25-mm to 76-mm) clearance should be provided around the pipe and the clear space filled with asphalt mastic or similar flexible waterproofing material.

A.15.1.7 Where water meters are in the supply lines to a sprinkler system, they should be rated to deliver the proper system demand. The amount of water supplied through a water meter varies with its size and type and might not provide the required demand, regardless of the water supply available.

A.15.1.8 Where connections are made from public waterworks systems, such systems should be guarded against possible contamination as follows *(see AWWA M14, Recommended Practice for Backflow Prevention and Cross Connection Control):*

(1) For private fire service mains with direct connections from public waterworks mains only or with booster pumps installed in the connections from the street mains, no tanks or reservoirs, no physical connection from other water supplies, no antifreeze or other additives of any kind, and with all drains discharging to atmosphere, dry well, or other safe outlets, no backflow protection is recommended at the service connection.
(2) For private fire service mains with direct connection from the public water supply main plus one or more of the following: elevated storage tanks or fire pumps taking suction from aboveground covered reservoirs or tanks (all storage facilities are filled or connected to public water only and the water in the tanks is to be maintained in a potable condition), an approved double check valve assembly is recommended.
(3) For private fire service mains directly supplied from public mains with an auxiliary water supply such as a pond or river on or available to the premises and dedicated to fire department use; or for systems supplied from public mains and interconnected with auxiliary supplies, such as pumps taking suction from reservoirs exposed to contamination or rivers and ponds; driven wells, mills, or other industrial water systems; or for systems or portions of systems where antifreeze or other solutions are used, an approved reduced pressure zone-type backflow preventer is recommended.



Heat pump detail:

Typical section of connections between sprinkler branch lines and heat pump

1. Branch line
2. "World-wide" model "E" globe valve
3. "Wunway" model "S" check valve
4. Dielectric union
5. "Farenheit" model #72 heat pump

Notes:

1. Wet pipe automatic sprinkler system with auxiliary connections for heating and air conditioning equipment. Ordinary hazard occupancy, 130 ft^2 maximum spacing.
2. A dotted line (...........) denotes auxiliary heating and air-conditioning piping.

Globe valve in auxiliary piping system

Check valve in auxiliary piping system

Heat pump in auxiliary piping system

FIGURE A.14.1.5(a) Working Plans for Circulating Closed-Loop Systems (Example 1).

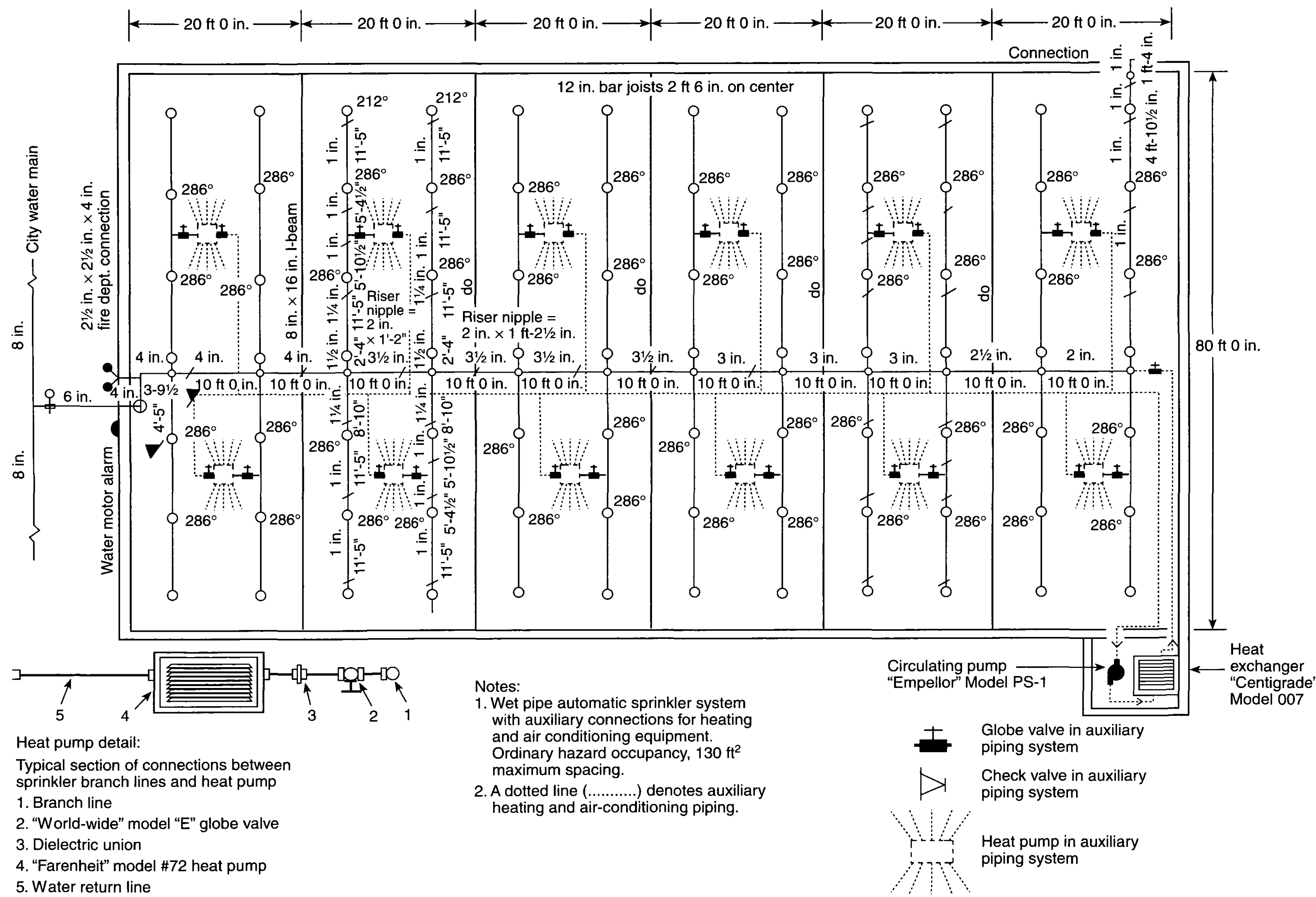


FIGURE A.14.1.5(b) Working Plans for Circulating Closed-Loop Systems (Example 2).

Hydraulic Calculations

for

ABC Company, employee garage

7499 Franklin Road

Charleston, SC

Contract No. 4001

Date 1-7-99

Design

Occupancy classification ORD. GR. 1

Density 0.15 gpm/ft^2

Area of application 1500 ft

Coverage per sprinkler 130 ft

Special sprinklers —

No. of sprinklers calculated 12

In-rack demand —

Hose streams 250 gpm

Total water required 510.4 gpm including hose streams

Name of contractor

Name of designer

Address

Authority having jurisdiction

FIGURE A.14.3.2(a) Summary Sheet.

A.15.2.1 Care should be taken in making water tests to be used in designing or evaluating the capability of sprinkler systems. The water supply tested should be representative of the supply that might be available at the time of a fire. For example, testing of public water supplies should be done at times of normal demand on the system. Public water supplies are likely to fluctuate widely from season to season and even within a 24-hour period. Allowance should be made for seasonal or daily fluctuations, for drought conditions, for possibility of interruption by flood, or for ice conditions in winter. Testing of water supplies also normally used for industrial use should be done while water is being drawn for industrial use. The range of industrial-use demand should be taken into account. In special situations where the domestic water demand could significantly reduce the sprinkler water supply, an increase in the size of the pipe supplying both the domestic and sprinkler water can be justified.

Future changes in water supplies should be considered. For example, a large, established, urban supply is not likely to change greatly within a few years. However, the supply in a growing suburban industrial park might deteriorate quite rapidly as greater numbers of plants draw more water.

Dead-end mains should be avoided, if possible, by arranging for mains supplied from both directions. When private fire service mains are connected to dead-end public mains, each situation should be examined to determine if it is practical to request the water utility to loop the mains in order to obtain a more reliable supply.

Testing of Water Supply. To determine the value of public water as a supply for automatic sprinkler systems, it is generally necessary to make a flow test to determine how much water can be discharged at a residual pressure at a rate sufficient to give the required residual pressure under the roof (with the volume flow hydraulically translated to the base of the riser) — that is, a pressure head represented by the height of the building plus the required residual pressure.

The proper method of conducting this test is to use two hydrants in the vicinity of the property. The static pressure should be measured on the hydrant in front of or nearest to the property and the water allowed to flow from the hydrant next nearest the property, preferably the one farthest from the source of supply if the main is fed only one way. The residual pressure will be that indicated at the hydrant where water is not flowing.

Referring to Figure A.15.2.1, the method of conducting the flow tests is as follows:

(1) Attach the gauge to the hydrant *(A)* and obtain static pressure.
(2) Either attach a second gauge to the hydrant *(B)* or use the pitot tube at the outlet. Have hydrant *(B)* opened wide and read pressure at both hydrants.
(3) Use the pressure at *(B)* to compute the gallons flowing and read the gauge on *(A)* to determine the residual pressure or that which will be available on the top line of sprinklers in the property.

Water pressure in pounds per square inch for a given height in feet equals height multiplied by 0.434.

In making flow tests, whether from hydrants or from nozzles attached to hose, always measure the size of the orifice. While hydrant outlets are usually 2½ in. (64 mm), they are sometimes smaller and occasionally larger. The Underwriters Laboratories play pipe is 1⅛ in. (29 mm) and 1¾ in. (44 mm) with the tip removed, but occasionally nozzles will be 1 in. (25.4 mm) or 1¼ in. (33 mm), and with the tip removed the opening can be only 1½ in. (38 mm).

The pitot tube should be held approximately one-half the diameter of the hydrant or nozzle opening away from the opening. It should be held in the center of the stream, except that in using hydrant outlets the stream should be explored to ascertain the average pressure.

For further information on water supply testing, see NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants.*

A.15.2.2 An automatically controlled vertical turbine pump taking suction from a reservoir, pond, lake, river, or well complies with 15.2.2.

See sections dealing with sprinkler equipment supervisory and waterflow alarm services in *NFPA 72, National Fire Alarm Code.*

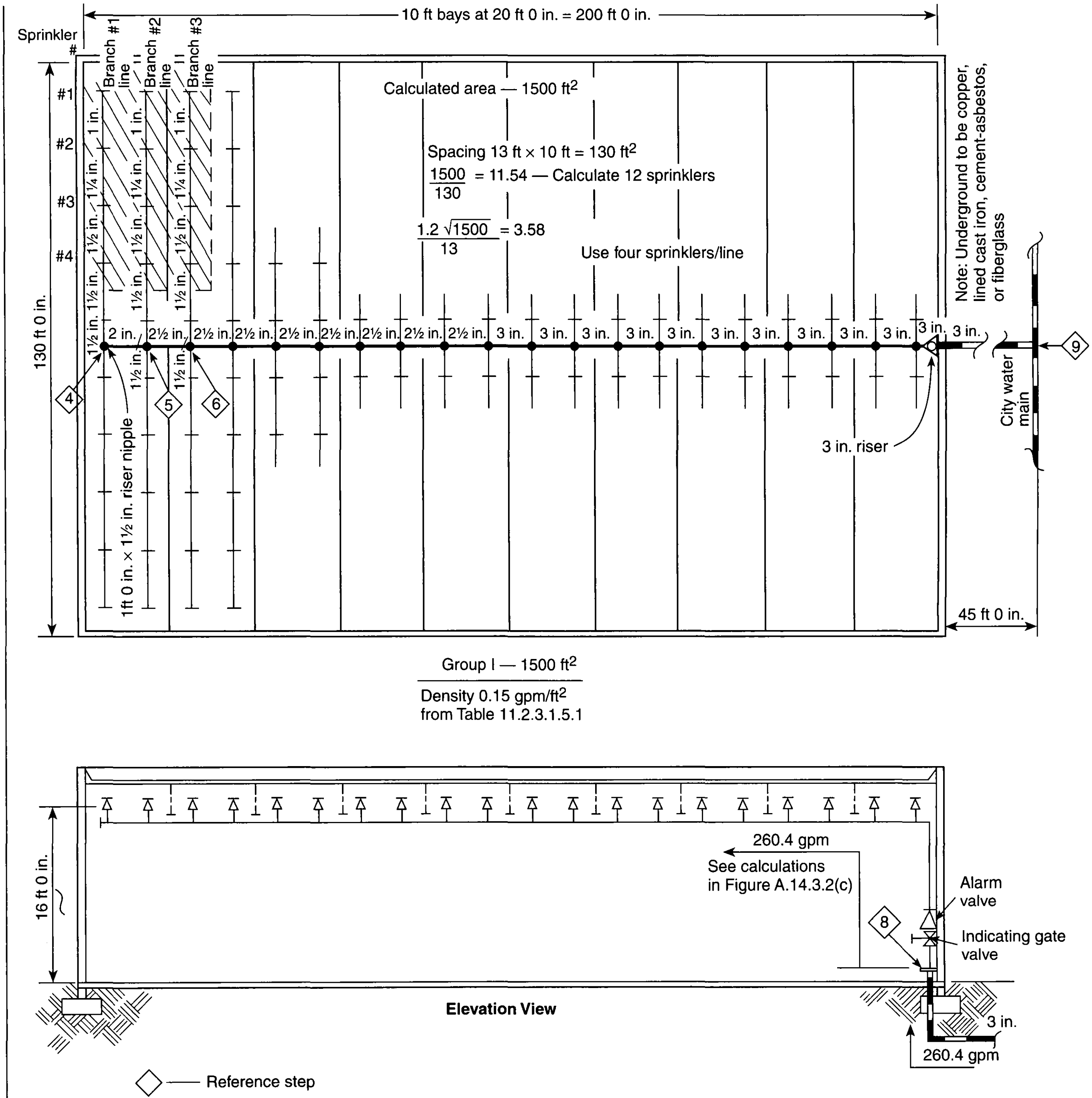


FIGURE A.14.3.2(b) Hydraulic Calculation Example (Plan View and Elevation View).

Contract Name GROUP I 1500 ft² Sheet 2 Of 3

Step No.	Nozzle Ident. and Location		Flow in gpm	Pipe Size	Pipe Fittings and Devices	Equiv. Pipe Length	Friction Loss psi Foot	Pressure Summary	Normal Pressure	D = 0.15 GPM/ft² Notes K = 5.6	Ref. Step
1	1	BL-1	q	1		L 13.0	C=120	P_t 12.1	P_t		
						F		P_e	P_v	Q = 130 x 0.15 = 19.5	
			Q 19.5			T 13.0	0.124	P_f 1.6	P_n	$P = (19.5/5.6)^2 = 12.1$ psi	
2	2		q 20.7	$1^1/_4$		L 13.0		P_t 13.7	P_t		
						F		P_e	P_v	$q = 5.65\sqrt{13.7}$	
			Q 40.2			T 13.0	0.125	P_f 1.6	P_n		
3	3		q 21.9	$1^1/_2$		L 13.0		P_t 15.3	P_t		4
						F		P_e	P_v	$q = 5.65\sqrt{15.3}$	
			Q 62.1			T 13.0	0.131	P_f 1.7	P_n		
4	4	DN RN	q 23.1	$1^1/_2$	2T-16	L 20.5		P_t 17.0	P_t		5
						F 16.0		P_e 0.4	P_v	$q = 5.65\sqrt{17}$	
			Q 85.2			T 36.5	0.236	P_f 8.6	P_n	$P_e = 1 \times 0.433$	
5		CM TO BL-2	q	2		L 10.0		P_t 26.0	P_t	$K = \frac{85.2}{\sqrt{26}}$	
						F		P_e	P_v		
			Q 85.2			T 10.0	0.07	P_f 0.7	P_n	K = 16.71	
6		BL-2 CM TO BL-3	q 86.3	$2^1/_2$		L 10.0		P_t 26.7	P_t		6
						F		P_e	P_v	$q = 16.71\sqrt{26.1}$	
			Q 171.5			T 10.0	0.107	P_f 1.1	P_n		
7		BL-3 CM	q 88.1	$2^1/_2$		L 70.0		P_t 27.8	P_t		
						F		P_e	P_v	$q = 16.7\sqrt{27.8}$	
			Q 259.6			T 70.0	0.231	P_f 16.2	P_n		
8		CM TO FIS	q	3	E5	L 119.0		P_t 44.0	P_t		8
					AV15	F 21		P_e 6.5	P_v	$P_e = 15 \times 0.433$	
			Q 259.6		GV1	T140.0	0.081	P_f 11.2	P_n		
9		THROUGH UNDER-GROUND TO CITY MAIN	q	3	E5	L 50.0	C=150	P_t 61.7	P_t	$F = F_{40} \times 1.51 \times F_c$	9
					GV1	F 27.6	TYPE'M'	P_e	P_v	$F_c = [2.981/3.068]^{4.87} = 0.869$	
			Q 259.6		T15	T 77.6	0.061	P_f 4.7	P_n	F = 21 x 1.51 x 0.869 F = 27.6	
			q			L		P_t 66.4	P_t		
						F		P_e	P_v		
			Q			T		P_f	P_n		
			q			L		P_t	P_t		
						F		P_e	P_v		
			Q			T		P_f	P_n		
								P_t			

FIGURE A.14.3.2(c) Hydraulic Calculations.

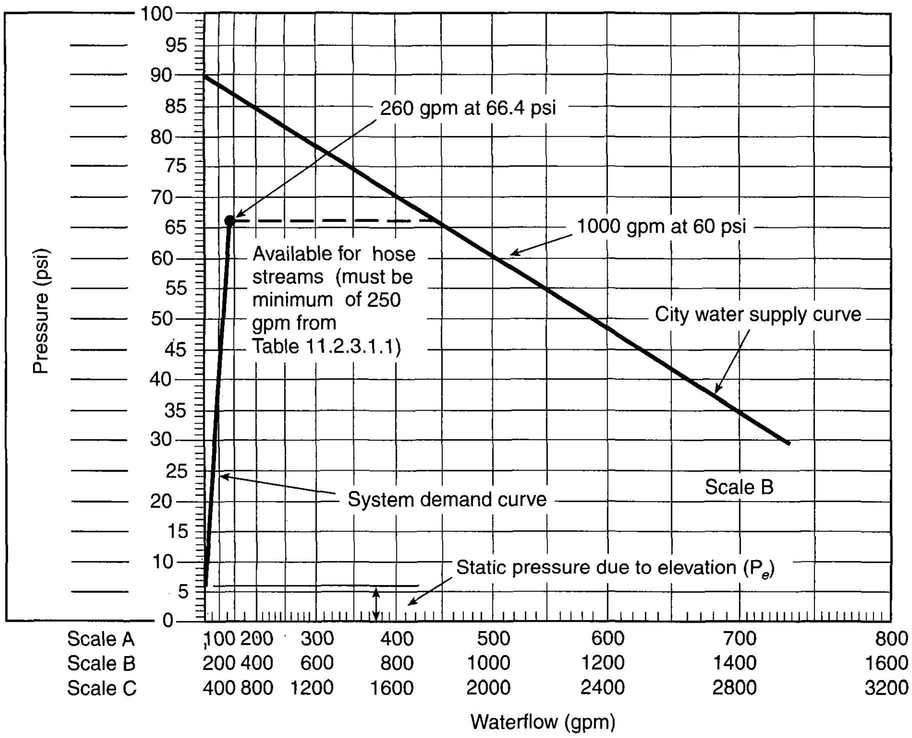


FIGURE A.14.3.2(d) Hydraulic Graph.

Contract no. ______________________ Sheet no. ________ of ________

Name and location ____

Reference	Nozzle type and location	Flow in gpm (L/min)	Pipe size (in.)	Fitting and devices	Pipe equivalent length	Friction loss psi/ft (bar/m)	Required psi (bar)	Normal Pressure	Notes
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	
		q			length		P_t	P_t	
					fitting		P_f	P_v	
		Q			total		P_e	P_n	

P_t = total pressure; P_f = friction loss pressure; P_v = velocity pressure; P_e = elevation pressure

FIGURE A.14.3.3 Sample Worksheet.

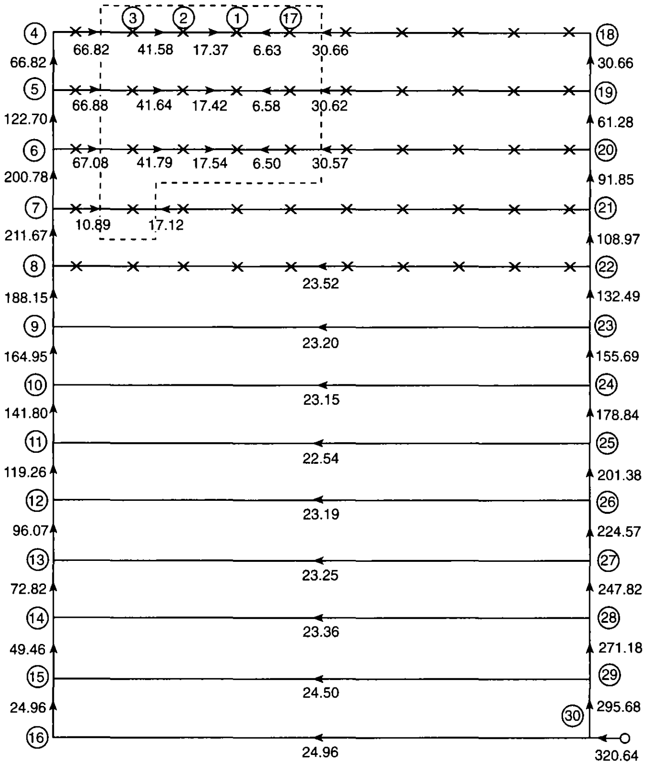


FIGURE A.14.3.3(15) Example of Hydraulically Remote Area — Grid System.

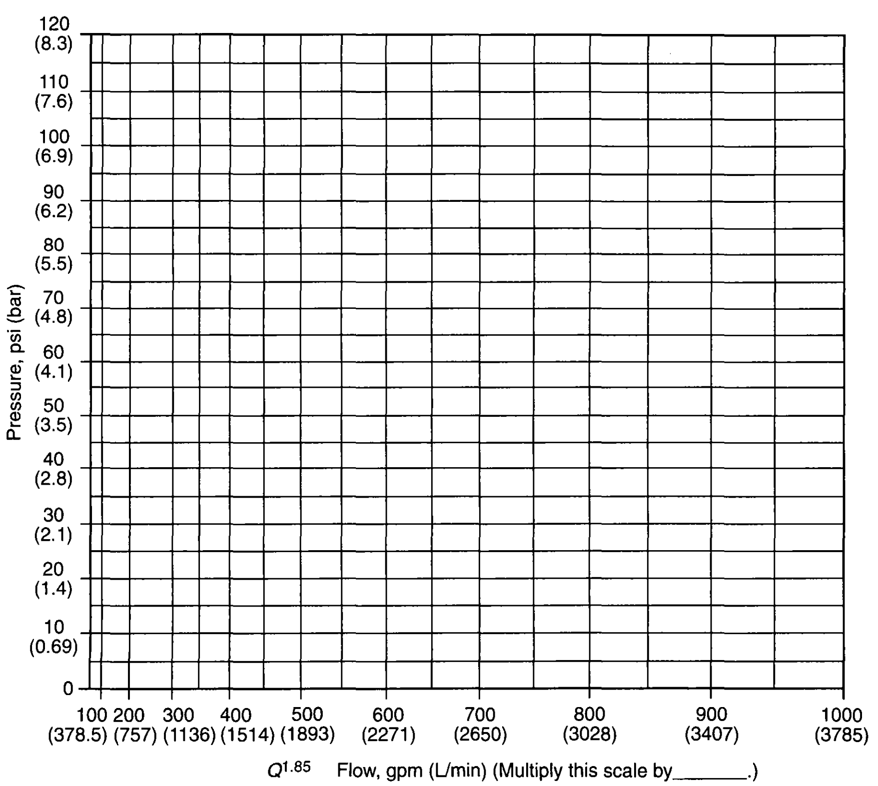


FIGURE A.14.3.4 Sample Graph Sheet.

A.15.2.3.3 For pipe schedule systems, the air pressure to be carried and the proper proportion of air in the tank can be determined from the following formulas where:

P = air pressure carried in pressure tank

A = proportion of air in tank

H = height of highest sprinkler above tank bottom

When the tank is placed above the highest sprinkler, use the following formula:

$$P = \frac{30}{A} - 15$$

If $A = 1/3$, then $P = 90 - 15 = 75$ lb psi

If $A = 1/2$, then $P = 60 - 15 = 45$ lb psi

If $A = 2/3$, then $P = 45 - 15 = 30$ lb psi

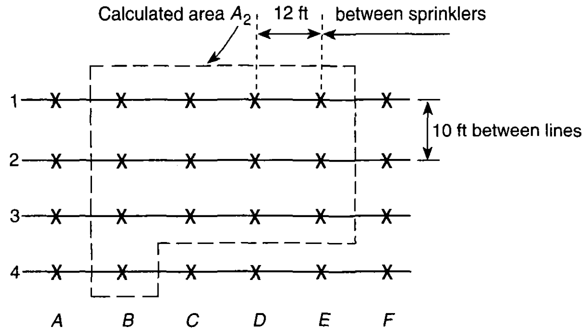
When the tank is below the level of the highest sprinkler, use the following formula:

$$P = \frac{30}{A} - 15 + \frac{0.434H}{A}$$

If $A = 1/3$, then $P = 75 + 1.30H$

If $A = 1/2$, then $P = 45 + 0.87H$

If $A = 2/3$, then $P = 30 + 0.65H$



Notes:

1. For gridded systems, the extra sprinkler (or sprinklers) on branch line 4 can be placed in any adjacent location from *B* to *E* at the designer's option.
2. For tree and looped systems, the extra sprinkler on line 4 should be placed closest to the cross main.

Assume a remote area of 1500 ft² with sprinkler coverage of 120 ft²

$$\text{Total sprinklers to calculate} = \frac{\text{Design area}}{\text{Area per sprinkler}}$$

$$= \frac{1500}{120} = 12.5\text{, calculate 13}$$

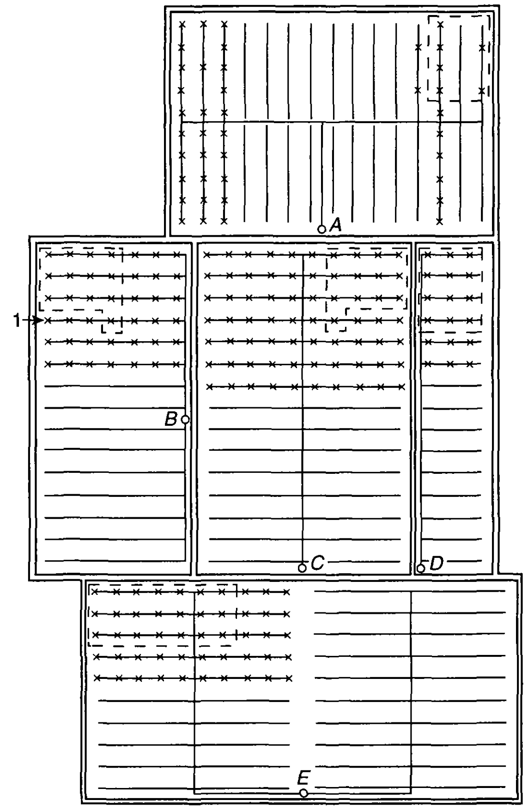
$$\text{Number of sprinklers on branch line} = \frac{1.2\sqrt{A}}{S}$$

Where:
A = design area
S = distance between sprinklers on branch line

$$\text{Number of sprinklers on branch line} = \frac{1.2\sqrt{1500}}{12} = 3.87$$

For SI units, 1 ft = 0.3048 m; 1 ft² = 0.0929 m².

FIGURE A.14.4.4 Example of Determining the Number of Sprinklers to Be Calculated.



1 This sprinkler is not in the selected area of operation.

FIGURE A.14.4.4.1(a) Example of Hydraulically Most Demanding Area.

The respective air pressures above are calculated to ensure that the last water will leave the tank at a pressure of 15 psi (1 bar) when the base of the tank is on a level with the highest sprinkler or at such additional pressure as is equivalent to a head corresponding to the distance between the base of the tank and the highest sprinkler when the latter is above the tank.

For hydraulically calculated systems, the following formula should be used to determine the tank pressure and ratio of air to water:

$$P_i = \frac{P_f + 15}{A} - 15$$

where:
P_i = tank pressure
P_f = pressure required from hydraulic calculations
A = proportion of air

Example: Hydraulic calculations indicate 75 psi (5.2 bar) is required to supply the system. What tank pressure will be required?

$$P_i = \frac{75+15}{0.5} - 15$$

$$P_i = 180 - 15 = 165 \text{ psi}$$

For SI units, 1 ft = 0.3048 m; 1 psi = 0.0689 bar.

In this case, the tank would be filled with 50 percent air and 50 percent water, and the tank pressure would be 165 psi (11.4 bar). If the pressure is too high, the amount of air carried in the tank will have to be increased.

Pressure tanks should be located above the top level of sprinklers but can be located in the basement or elsewhere.

A.16.2.1.12 Hydrostatic tests should be made before the joints are covered so that any leaks can be readily detected. Thrust blocks should be sufficiently hardened before hydrostatic testing is begun. If the joints are covered with backfill prior to testing, the contractor remains responsible for locating and correcting any leakage in excess of that permitted.

The pipeline should be prepared 24 hours prior to testing by filling it with water in such a manner as to remove all air. The test pressure should be applied to stabilize the system, which should minimize losses due to entrapped air, changes in water temperature, distention of components under pressure, movement of gaskets, and absorption of air by the water and water by the pipe wall.

A.16.2.1.15 Valves isolating the section to be tested might not be "drop-tight." When such leakage is suspected, test blanks of the type required in 16.2.1.15 should be used in a manner that includes the valve in the section being tested.

A.16.2.3.2 When the acceptance test is being performed during freezing conditions, a partial flow trip test should be conducted at that time and the full flow trip test specified should be conducted as soon as conditions permit.

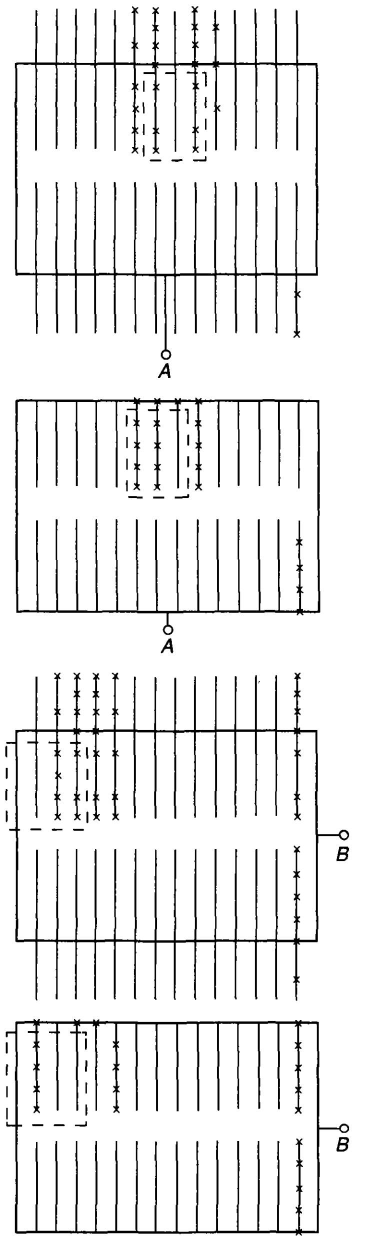


FIGURE A.14.4.4.1(b) Example of Hydraulically Most Demanding Area.

A.16.5 See Figure A.16.5.

A.17.1.3(4) The backbone of the fire protection philosophy for U.S. flagged vessels and passenger vessels that trade internationally is limiting a fire to the compartment of origin by passive means. Materials that do not withstand a 1-hour fire exposure when tested in accordance with ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* are considered "heat sensitive." *[See Figure A.17.1.3(4).]*

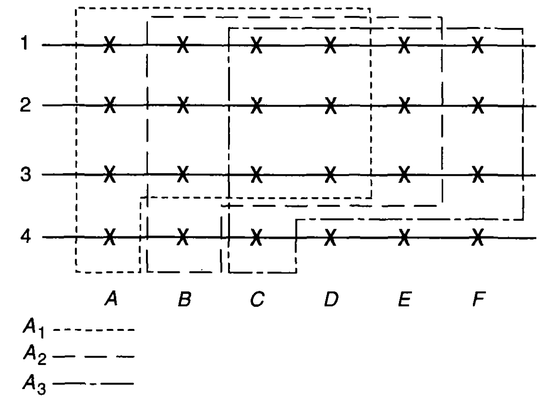


FIGURE A.14.4.4.2 Example of Determining the Most Remote Area for a Gridded System.

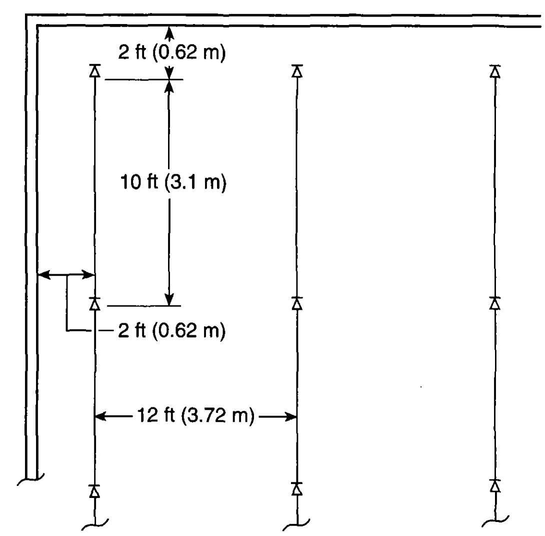


FIGURE A.14.4.4.3.2 Sprinkler Design Area.

Table A.14.5.4 Extra Hazard Pipe Schedule

Steel		Copper	
1 in.	1 sprinkler	1 in.	1 sprinkler
1¼ in.	2 sprinklers	1¼ in.	2 sprinklers
1½ in.	5 sprinklers	1½ in.	5 sprinklers
2 in.	8 sprinklers	2 in.	8 sprinklers
2½ in.	15 sprinklers	2½ in.	20 sprinklers
3 in.	27 sprinklers	3 in.	30 sprinklers
3½ in.	40 sprinklers	3½ in.	45 sprinklers
4 in.	55 sprinklers	4 in.	65 sprinklers
5 in.	90 sprinklers	5 in.	100 sprinklers
6 in.	150 sprinklers	6 in.	170 sprinklers

For SI units, 1 in. = 25.4 mm.

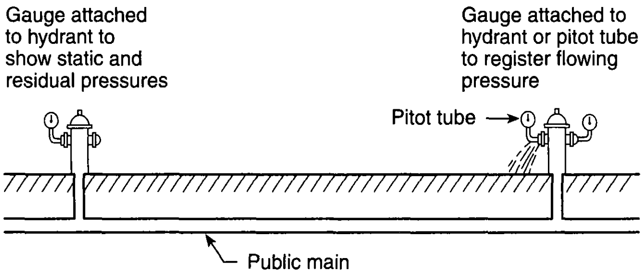


FIGURE A.15.2.1 Method of Conducting Flow Tests.

This system as shown on .... company

print no .... dated ....

for ....

at .... contract no ....

is designed to discharge at a rate of .... gpm/ft²

(L/min/m²) of floor area over a maximum area of ....

ft² (m²) when supplied with water at a rate of ....

gpm (L/min) at .... psi (bar) at the base of the riser.

Hose stream allowance of .... gpm (L/min)

is included in the above.

Occupancy classification ....

Commodity classification ....

Maximum storage height ....

FIGURE A.16.5 Sample Nameplate.

A.17.1.3(8) Some types of sprinkler systems can closely resemble marine systems, such as a system installed on a floating structure that has a permanent water supply connection to a public main. For these types of systems, judgment should be used in determining if certain aspects of Chapter 17 are applicable.

A.17.1.3(9) A marine thermal barrier is typically referred to as a B-15 boundary.

A.17.1.4 In addition to the examples provided in A.5.1, Table A.17.1.4 provides additional examples of occupancy definitions of typical shipboard spaces.

The classifications in Table A.17.1.4 are not meant to be applied without giving consideration to the definition of each occupancy hazard given in the standard. Table A.17.1.4 is general guidance for classification of typical spaces. Where a space is outfitted such that the occupancy definitions indicate that another classification would be more appropriate, the most

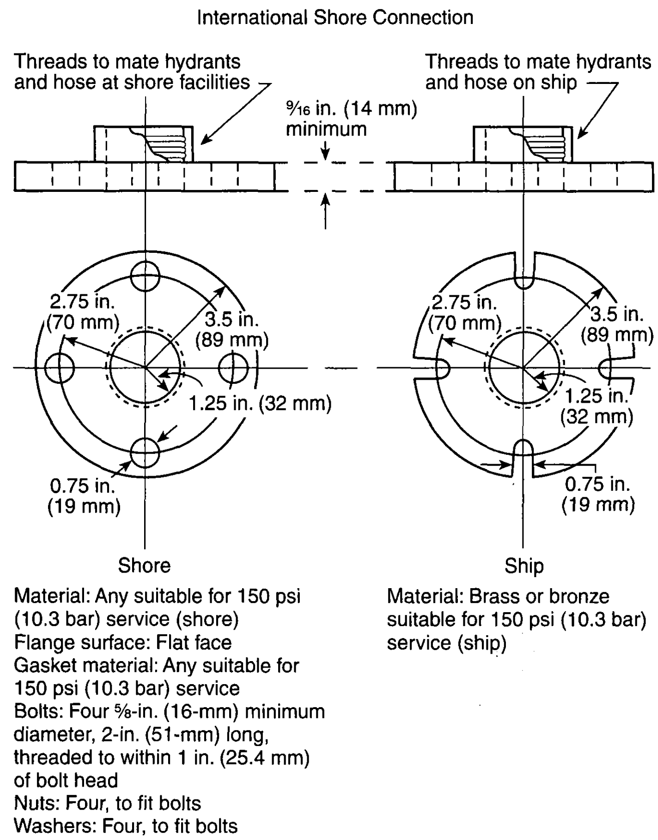


FIGURE A.17.1.3(4) International Shore Fire Connection.

representative and most demanding occupancy classification should be used. For example, it would certainly be possible to outfit a stateroom to require upgrading the occupancy to ordinary hazard, Group 1.

When a vessel undergoes modifications, alterations, or service changes that significantly affect the fire risk of the occupancy of one or more compartments, the occupancy classification should be reevaluated to determine if it has changed.

A.17.1.5 Experience has shown that structures that are partially sprinklered can be overrun by well-developed fires originating in unsprinklered areas. Therefore, the entire vessel should be sprinklered whenever sprinkler systems are considered.

A.17.2.1 Sprinklers with a nominal K-factor of 2.8 or less coupled with a system strainer minimize the potential for clogging.

A.17.2.2 Where a marine thermal barrier is penetrated, limiting the opening around the sprinkler pipe to 1⁄16 in. (1.6 mm) is considered as meeting this requirement.

A.17.2.4.1 When nonferrous materials are used, consideration should be given to protecting against galvanic corrosion where the nonferrous materials connect to steel pipe. Consideration should also be given to protection against galvanic corrosion from pipe hangers in areas of high humidity.

Table A.17.1.4 Examples of Shipboard Space Occupancy Classification

	Space Types Included		
Occupancy Type	**CFR**[1]	**SOLAS**[2]	**Examples**
Light hazard	1[3], 2, 3, 4, 5, 6, 7, 8[4], 13	1[3], 2, 3, 4, 5, 6, 7, 8, 9	Accommodation spaces Small pantries
Ordinary hazard (Group 1)	8[4], 9[4]	12, 13[4]	Galleys Storage areas Sales shops Laundries Pantries with significant storage
Ordinary hazard (Group 2)	9[4], 11[4]	12[4], 13[4]	Sales shops Storage areas Stages (with sets) Machine shops
Extra hazard (Group 1)	1, 9[4], 10, 11[4]	1, 12[4], 13[4]	Auxiliary machinery — limited combustible liquids[5] Steering rooms — combustible hydraulic fluid in use[5]
Extra hazard (Group 2)	1, 9[4], 10, 11[4]	1, 12[4], 13[4]	Auxiliary machinery — with combustible liquids[5] Machinery spaces[5]

[1] Space type designations are given in 46 CFR 72.05-5.
[2] Space type designations are given in the *International Convention for the Safety of Life at Sea*, 1974 (SOLAS 74), as amended, regulations II-2/3 and II-2/26.
[3]Primarily for accommodation-type control stations, such as the wheel house, which would not include generator rooms or similar-type spaces.
[4]Depends on storage type, quantity, and height and distance below sprinkler.
[5] Automatic sprinklers typically will not be the primary means of protection in these areas; total flooding systems are usually used.

The piping between the sea chest and the sprinkler zone valves are likely to see the frequent flow of salt water when testing. Sprinkler zone piping will rarely, if ever, be exposed to salt water. In such an event, NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, requires flushing of the piping. Even if the piping is not flushed, the salt water will not be replenished and will lose oxygen content in fairly short order.

Even if galvanized, the failure from corrosion from the interior of the pipe is likely to be at all threaded connections, welded assembly connections, and where brass sprinklers thread into ferrous pipe. Only hot dipped galvanized after fabrication of assembly (as opposed to simply hot dipped galvanized pipe and fittings) will protect against some of those failures. Hot dipped galvanized after fabrication of assembly is practical from the sea chest to the sprinkler manifold where spaces are open and pipe is relatively large and uses flanged takedown joints instead of threaded unions. Hot dipped galvanized after fabrication of assembly is not practical in the sprinkler zone pipe where it is mainly field fit.

A.17.2.5.1 When designing supports, the selection and spacing of pipe supports should take into account the pipe dimensions, mechanical and physical properties of piping materials and supports, operating temperature, thermal expansion effects, external loads, thrust forces, vibration, maximum accelerations, differential motions to which the system might be subjected, and the type of support.

The route of the vessel is intended to be descriptive of its usual operating area. For example, expected motion of the system on an ocean vessel is expected to be considerably greater than the motion of a vessel that operates on a river. A vessel that operates within the confines of any of the Great Lakes is expected to subject the system pipe to greater motion than would a vessel that operates on a lake such as Lake Tahoe.

It is recommended that the designer review the requirements for automatic sprinkler systems that are subject to earthquakes. While it is obvious that shipboard motions and accelerations differ from those that occur during an earthquake, the general principle of protecting the piping system against damage applies. Individual hanger design, however, will be very similar.

Earthquake protection does not apply to ships; however, motions are similar to those that a ship will experience in a seaway. The design principles discussed in this section should be used as a guide for shipboard system design.

A.17.2.5.3 Use of heat-sensitive materials for pipe hangers and supports might be desirable in some cases. Where heat-sensitive materials are used, the hangers and supports should be adequately protected by either the direct application of insulation or installation behind a marine thermal barrier. Insulation materials applied directly to hangers should be insulated in accordance with the method provided in Society of Naval Architects and Marine Engineers Technical Research Bulletin 2-21, "Aluminum Fire Protection Guidelines."

A.17.2.5.4 Consideration should be given to increasing the size of rods and U-hooks as necessary, to account for service and operational loading, including ship motion and vibrations.

A.17.2.6.1 Shipboard installations will normally require more than one valve per water supply. Locking valves in the open position is not an acceptable substitute for the requirement of 17.2.6.1 but can be done in addition to the supervision requirement.

A.17.2.7.1 International Shore Connections are portable universal couplings that permit connections of shipboard sprinkler or firemain systems between one ship and another or between a shore facility and a ship. Both the ship and the shore facility are expected to have an International Shore Connection fitting such that in an emergency they can be attached to their respective fire hoses and bolted together to permit charging the ship's system. It must be portable to accommodate hose-to-hose connection and allow assistance from any position.

Installation of an additional fire boat connection might be required on-board vessels whose route is such that regular access to fire boats is possible. An additional fire boat connection might not be necessary where fire boats are equipped to connect to the regular fire department connection. *(See A.17.2.7.7.)*

A.17.2.7.7 Selection of the pipe thread for the fire department connection should be done very carefully. It is recommended that a 2½-in. (63.5-mm) siamese connection with National Standard Hose Thread be used since a majority of fire department hose lines will be compatible with this thread. However, it must be noted that some fire jurisdictions might not be compatible with a connection of this type. Serious consideration should be given to the vessel's typical operating area. Precautions and planning should avert the possibility of the vessel being forced ashore by fire at a location where the fire department equipment is not compatible with this connection. Carriage of extra fittings and pre-voyage arrangements with all applicable jurisdictions should be considered. The International Shore Connection is required to ensure that all vessels fitted with sprinkler systems have at least one type of common connection.

A.17.3.1 Special consideration should be given to the installation of relief valves in all wet pipe systems. Ambient ship temperatures can vary greatly depending on operating environment, duration of voyage, and failure of climate control systems.

A.17.4.2 Areas fitted primarily with multiple staterooms and corridors should be considered sleeping accommodation areas.

A.17.4.4 If combustibles are present such that they constitute a threat, the space should be sprinklered. One example would be the presence of large bundles of unsheathed computer or electrical cable. Typical amounts of lighting or control cabling should not be considered to constitute a fire threat.

A.17.4.10.1(4) Because of its melting point, brazing would be considered heat sensitive. The criterion of this paragraph is intended to permit brazed joints without requiring that they be installed behind a marine thermal barrier, while maintaining the fire endurance performance as stated in 17.4.10.1 under reasonably foreseeable failure modes.

A.17.4.12.1 While not required, a dual annunciator alarm panel system is recommended. One panel should show the piping system layout and indicate status of zone valves, tank pressures, water supply valves, pump operation, and so forth. The second panel should show the vessel's general arrangement and indicate status of waterflow (i.e., fire location) alarms.

A.17.5.2 For example, a design area of 1500 ft^2 (139.3 m^2) is used to design a sprinkler system for an unobstructed light hazard occupancy. In this case, the system must supply at least seven sprinklers that are installed within that area. If eight sprinklers are installed to protect windows within this design area, the water demand of these sprinklers is added to the total water demand. Thus, 15 sprinklers must be supplied by this system.

A.17.5.3 Hose stream flow need not be added to the water demand. The water supply for fire streams is supplied by separate fire pump(s) that supply the vessel's fire main.

A.17.6.4 In vessels, the elevation of sprinklers with respect to the water supply varies as the vessel heels to either side or trims by the bow or stern. The water demand requirements can be increased or decreased under these conditions. This requirement aligns the operational parameters of this safety system with that required for other machinery vital to the safety of the vessel.

A.17.7.2.7 The purpose of this is to ensure that the pressure tank air supply will not keep the tank "fully" pressurized while water is expelled, thus preventing pump actuation.

A.17.7.3.3 NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* requires that fire pumps furnish not less than 150 percent of their rated capacity at not less than 65 percent of their rated heat. The intention of the requirement of 17.7.3.3 is to limit designers to 120 percent of the rated capacity of the pump to provide an additional factor of safety for marine systems.

A.17.7.3.12.2(1) Pumps should not be located within the same compartment. However, where this is not reasonable or practical, special attention should be given to protecting pumps such that a single failure will not render the sprinkler system inoperative. *[See Figure A.17.7.3.12.2(1).]*

A.17.7.3.13 See Figure A.17.7.3.13.

A.17.7.4.6 This procedure should be used to qualify each water supply to which the vessel is to be attached. For example, this might require testing of multiple hydrants or connections in the same mooring area. The pressure loss effect of the hose or piping leading from the water supply to the ship should also be considered when qualifying each hydrant.

A.18.1 *Impairments.* Before shutting off a section of the fire service system to make sprinkler system connections, notify the authority having jurisdiction, plan the work carefully, and assemble all materials to enable completion in the shortest possible time. Work started on connections should be completed without interruption, and protection should be restored as promptly as possible. During the impairment, provide emergency hose lines and extinguishers and maintain extra watch service in the areas affected.

When changes involve shutting off water from any considerable number of sprinklers for more than a few hours, temporary water supply connections should be made to sprinkler systems so that reasonable protection can be maintained. In adding to old systems or revamping them, protection should be restored each night so far as possible. The members of the private fire brigade as well as public fire departments should be notified as to conditions.

Maintenance Schedule. The items shown in Table A.18.1 should be checked on a routine basis.

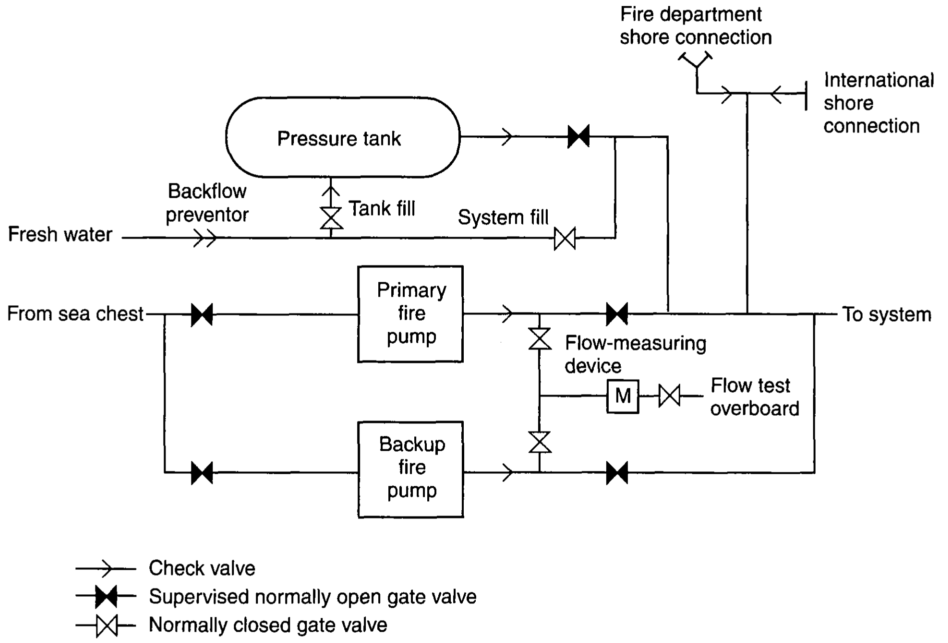


FIGURE A.17.7.3.12.2(1) Abbreviated Example of a Dual Fire Pump Water Supply.

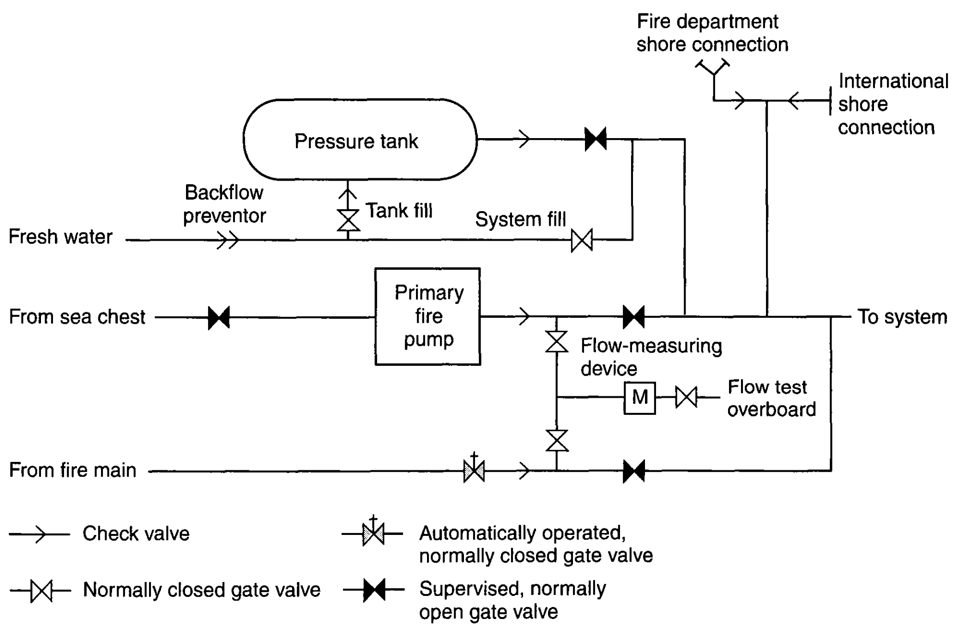


FIGURE A.17.7.3.13 Abbreviated Example of a Water Supply with Fire Pump Backup.

Table A.18.1 Maintenance Schedule

Parts	Activity	Frequency
Flushing piping	Test	5 years
Fire department connections	Inspection	Monthly
Control valves	Inspection	Weekly — sealed
	Inspection	Monthly — locked
	Inspection	Monthly — tamper switch
	Maintenance	Yearly
Main drain	Flow test	Quarterly — annual
Open sprinklers	Test	Annually
Pressure gauge	Calibration test	
Sprinklers	Test	50 years
Sprinklers — high temperature	Test	5 years
Sprinklers — residential	Test	20 years
Waterflow alarms	Test	Quarterly
Preaction/deluge detection system	Test	Semiannually
Preaction/deluge systems	Test	Annually
Antifreeze solution	Test	Annually
Cold weather valves	Open and close valves	Fall, close; spring, open
Dry/preaction/deluge systems		
Air pressure and water pressure	Inspection	Weekly
Enclosure	Inspection	Daily — cold weather
Priming water level	Inspection	Quarterly
Low-point drains	Test	Fall
Dry pipe valves	Trip test	Annually — spring
Dry pipe valves	Full flow trip	3 years — spring
Quick-opening devices	Test	Semiannually

Annex B Miscellaneous Topics

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Figure B.1 shows acceptable methods for interconnection of the fire protection and domestic water supply.

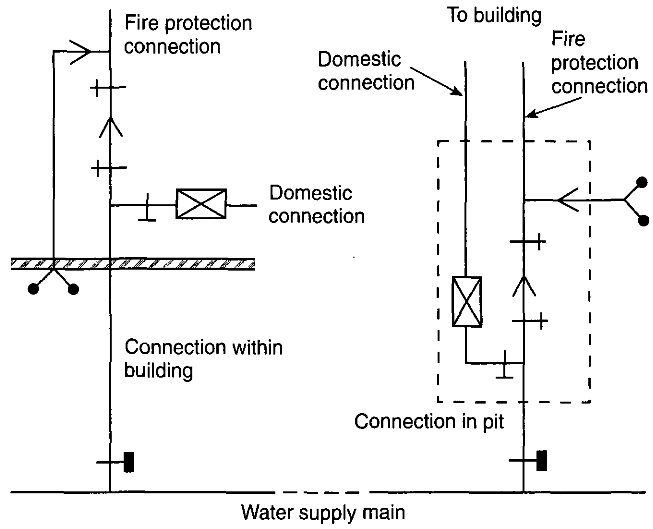


FIGURE B.1 Permitted Arrangements Between the Fire Protection Water Supply and the Domestic Water Supply.

B.2 Sprinkler System Performance Criteria.

B.2.1 Sprinkler system performance criteria have been based on test data. The factors of safety are generally small, are not definitive, and can depend on expected (but not guaranteed) inherent characteristics of the sprinkler systems involved. These inherent factors of safety consist of the following:

(1) The flow-declining pressure characteristic of sprinkler systems whereby the initial operating sprinklers discharge at a higher flow than with all sprinklers operating within the designated area.
(2) The flow-declining pressure characteristic of water supplies, which is particularly steep where fire pumps are the water source. This characteristic similarly produces higher than design discharge at the initially operating sprinklers.

The user of these standards can elect an additional factor of safety if the inherent factors are not considered adequate.

B.2.1.1 Performance-specified sprinkler systems, as opposed to scheduled systems, can be designed to take advantage of multiple loops or gridded configurations. Such configurations result in minimum line losses at expanded sprinkler spacing, in contrast to the older tree-type configurations, where advantage cannot be taken of multiple path flows.

Where the water supply characteristics are relatively flat with pressures being only slightly above the required sprinkler pressure at the spacing selected, gridded systems with piping designed for minimal economic line losses can all but eliminate the inherent flow-declining pressure characteristic generally assumed to exist in sprinkler systems. In contrast, the economic design of a tree-type system would likely favor a system design with closer sprinkler spacing and greater line losses, demonstrating the inherent flow-declining pressure characteristic of the piping system.

Elements that enter into the design of sprinkler systems include the following:

(1) Selection of density and area of application
(2) Geometry of the area of application (remote area)
(3) Permitted pressure range at sprinklers
(4) Determination of the water supply available
(5) Ability to predict expected performance from calculated performance
(6) Future upgrading of system performance
(7) Size of sprinkler systems

In developing sprinkler specifications, each of these elements needs to be considered individually. The most conservative design should be based on the application of the most stringent conditions for each of the elements.

B.2.1.2 Selection of Density and Area of Application. Specifications for density and area of application are developed from NFPA standards and other standards. It is desirable to specify densities rounded upward to the nearest 0.005 gpm/ft^2 (0.2 mm/min).

Prudent design should consider reasonable-to-expect variations in occupancy. This design would include not only variations in type of occupancy, but also, in the case of warehousing, the anticipated future range of materials to be stored, clearances, types of arrays, packaging, pile height, and pile stability, as well as other factors.

Design should also consider some degree of adversity at the time of a fire. To take this into account, the density and/or area of application can be increased. Another way is to use a dual-performance specification where, in addition to the normal primary specifications, a secondary density and area of application are specified. The objective of such a selection is to control the declining pressure-flow characteristic of the sprinkler system beyond the primary design flow.

A case can be made for designing feed and cross mains to lower velocities than branch lines to achieve the same result as specifying a second density and area of application.

B.2.1.3 Geometry of the Area of Application (Remote Area). It is expected that, over any portion of the sprinkler system equivalent in size to the area of application, the system will achieve the minimum specified density for each sprinkler within that area.

Where a system is computer-designed, ideally the program should verify the entire system by shifting the area of application the equivalent of one sprinkler at a time so as to cover all portions of the system. Such a complete computer verification of performance of the system is most desirable, but unfortunately not all available computer verification programs currently do this.

This selection of the proper Hazen-Williams coefficient is important. New unlined steel pipe has a Hazen-Williams coefficient close to 140. However, it quickly deteriorates to 130 and, after a few years of use, to 120. Hence, the basis for normal design is a Hazen-Williams coefficient of 120 for steel-piped wet systems. A Hazen-Williams coefficient of 100 is generally used for dry pipe systems because of the increased tendency for deposits and corrosion in these systems. However, it should be realized that a new system will have fewer line losses than calculated, and the distribution pattern will be affected accordingly.

Conservatism can also be built into systems by intentionally designing to a lower Hazen-Williams coefficient than that indicated.

B.2.1.4 Ability to Predict Expected Performance from Calculated Performance. Ability to accurately predict the performance of a complex array of sprinklers on piping is basically a function of the pipe line velocity. The greater the velocity, the greater is the impact on difficult-to-assess pressure losses. These pressure losses are presently determined by empirical means that lose validity as velocities increase. This is especially true for fittings with unequal and more than two flowing ports.

The inclusion of velocity pressures in hydraulic calculations improves the predictability of the actual sprinkler system performance. Calculations should come as close as practicable to predicting actual performance. Conservatism in design should be arrived at intentionally by known and deliberate means. It should not be left to chance.

B.2.1.5 Future Upgrading of System Performance. It is desirable in some cases to build into the system the capability to achieve a higher level of sprinkler performance than needed at present. If this is to be a consideration in conservatism, consideration needs to be given to maintaining sprinkler operating pressures on the lower side of the optimum operating range and/or designing for low pipe line velocities, particularly on feed and cross mains, to facilitate future reinforcement.

Annex C Explanation of Test Data and Procedures for Rack Storage

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Annex C provides an explanation of the test data and procedures that led to the development of sprinkler system discharge criteria for rack storage applications. Numbers in brackets refer to paragraphs in the text.

C.2 [5.6] A review of full-scale fire tests run on the standard commodity (double tri-wall carton with metal liner), of Hallmark products and 3M products (e.g., abrasives, pressure-sensitive tapes of plastic fiber, and paper), and of the considerable number of commodity tests conducted provides a guide for commodity classifications. Such guidance is not related to any other method of classification of materials; therefore, sound engineering judgment and analysis of the commodity and the packaging should be used when selecting a commodity classification.

C.3 [8.13.3.1] Tests 71, 73, 81, 83, 91, 92, 95, and 100 in the 20-ft (6.1-m) high array involving a single level of in-rack sprinklers were conducted without heat or water shields. Results were satisfactory.

Test 115 was conducted with two levels of sprinklers in racks with shields. Test 116, identical to Test 115 but without water shields, produced a lack of control. Visual observation of lower level in-rack sprinklers that did not operate although they were in the fire area indicated a need for water shields.

Tests 115 and 116 were conducted to investigate the necessity for water shields where multiple levels of in-rack sprinklers are installed. Where water shields were not installed in Test 116, the fire jumped the aisle, and approximately 76 boxes were damaged. In Test 115 with water shields, the fire did not jump the aisle, and only 32 boxes were damaged. Water shields are, therefore, suggested wherever multiple levels of in-rack sprinklers are installed, except for installations with horizontal barriers or shelves that serve as water shields.

C.4 [8.16.1.8] The time of operation of the first sprinkler varied from 52 seconds to 3 minutes and 55 seconds, with most tests under 3 minutes, except in Test 64 (Class III), where the first sprinkler operated in 7 minutes and 44 seconds. Fire detection more sensitive than waterflow is, therefore, considered necessary only in exceptional cases.

C.5 [8.16.5.1] In most tests conducted, it was necessary to use small hose for mop-up operations. Small hose were not used in the high-expansion foam test.

Test 97 was conducted to evaluate the effect of dry pipe sprinkler operation. Test results were approximately the same as the base test with a wet pipe system. A study of NFPA records, however, indicates an increase in area of operation of 30 percent to be in order for dry pipe systems as compared with wet pipe systems.

C.6 [12.1.1] Tests were conducted as a part of this program with eave line windows or louvers open to simulate smoke and heat venting. These tests opened 87.5 percent and 91 percent more sprinklers than did comparative tests without windows or louvers open. Venting tests that have been conducted in other programs were without the benefit of sprinkler protection and, as such, are not considered in this report, which covers only buildings protected by sprinklers. The design curves are based upon the absence of roof vents or draft cur-

tains in the building. During mop-up operations, ventilating systems, where installed, should be capable of manual exhaust operations.

C.7 [12.1.9.1.3] No tests were conducted with idle pallets in racks using standard spray sprinklers. However, tests were conducted using ESFR and large drop sprinklers. Such storage conceivably would introduce fire severity in excess of that contemplated by protection criteria for an individual commodity classification.

C.8 [12.2.1.2, 12.3.2.1.7, 12.3.3.1.11] In all valid tests with double-row racks, sprinkler water supplies were shut off at approximately 60 minutes. In only one test did the last sprinkler operate in excess of 30 minutes after ignition; the last sprinkler operated in excess of 25 minutes in three tests, with the majority of tests involving the last sprinkler operating within 20 minutes.

C.9 [12.3] The discharge criteria of Section 12.3 uses as a basis the large-scale fire test series conducted at the Factory Mutual Research Center, West Glocester, Rhode Island.

The test building is approximately 200 ft × 250 ft (61 m × 76 m) [50,000 ft^2 (4.65 km^2) in area], of fire-resistive construction, and contains a volume of approximately 2.25 million ft^3 (63,720 m^3), the equivalent of a 100,000-ft^2 (9.29-km^2) building that is 22.5 ft (6.86 m) high. The test building has two primary heights beneath a single large ceiling. The east section is 30 ft (9.1 m) high, and the west section is 60 ft (18.29 m) high.

The test series for storage height of 20 ft (6.1 m) was conducted in the 30-ft (9.1-m) section with clearances from the top of storage to the ceiling nominally 10 ft (3.1 m).

Doors at the lower and intermediate levels and ventilation louvers at the tops of walls were kept closed during the majority of the fire tests, which minimized the effect of exterior conditions.

The entire test series was fully instrumented with thermocouples attached to rack members, simulated building columns, bar joists, and the ceiling.

Racks were constructed of steel vertical and horizontal members designed for 4000-lb (1814-kg) loads. Vertical members were 8 ft (2.4 m) on center for conventional racks and 4 ft (1.2 m) on center for simulated automated racks. Racks were 3½ ft (1.07 m) wide with 6-in. (152.4-mm) longitudinal flue space for an overall width of 7½ ft (2.29 m). Simulated automated racks and slave pallets were used in the main central rack in the 4-ft (1.2-m) aisle tests. Conventional racks and conventional pallets were used in the main central rack in the 8-ft (2.4-mm) aisle tests. The majority of the tests were conducted with 100-ft^2 (9.29-m^2) sprinkler spacing.

The test configuration for storage heights of 15 ft (4.6 m), 20 ft (6.1 m), and 25 ft (7.6 m) covered an 1800-ft^2 (167.2-m^2) floor area, including aisles between racks. Tests that were used in producing this standard limited fire damage to this area. The maximum water damage area anticipated in the standard is 6000 ft^2 (557.4 m^2), the upper limit of the design curves.

The test data shows that, as density is increased, both the extent of fire damage and sprinkler operation are reduced. The data also indicates that, with sprinklers installed in the racks, a reduction is gained in the area of fire damage and sprinkler operations (e.g., water damage).

Table C.9 illustrates these points. The information shown in the table is taken from the test series for storage height of 20 ft (6.1 m) using the standard commodity.

The fact that there is a reduction in both fire damage and area of water application as sprinkler densities are increased or where sprinklers are installed in racks should be considered carefully by those responsible for applying this standard to the rack storage situation.

In the test for storage height of 25 ft (7.6 m), a density of 0.55 gpm/ft^2 (22.4 mm/min) produced 42 percent, or 756 ft^2 (70.26 m^2), fire damage in the test array and a sprinkler-wetted area of 1400 ft^2 (130.1 m^2). Lesser densities would not be expected to achieve the same limited degree of control. Therefore, if the goal of smaller areas of fire damage is to be achieved, sprinklers in racks should be considered.

The test series for storage height over 25 ft (7.6 m) was conducted in the 60-ft (18.3-m) section of the test building with nominal clearances from the top of storage to the ceiling of either 30 ft (9.1 m) or 10 ft (3.1 m).

Doors at the lower and intermediate levels and ventilation louvers at the top of walls were kept closed during the fire tests, which minimized the effect of exterior wind conditions.

The purpose of the tests for storage height over 25 ft (7.6 m) was to accomplish the following:

(1) Determine the arrangement of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire
(2) Determine other protective arrangements, such as high-expansion foam, that provide control of the fire

Control was considered to have been accomplished if the fire was unlikely to spread from the rack of origin to adjacent racks or spread beyond the length of the 25-ft (7.6-m) test rack. To aid in this judgment, control was considered to have been achieved if the fire failed to exhibit the following characteristics:

(1) Jump the 4-ft (1.2-m) aisles to adjoining racks
(2) Reach the end face of the end stacks (north or south ends) of the main rack

Control is defined as holding the fire in check through the extinguishing system until the commodities initially involved are consumed or until the fire is extinguished by the extinguishing system or manual aid.

The standard commodity as selected in the 20-ft (6.1-m) test series was used in the majority of tests for storage over 25 ft (7.6 m). Hallmark products and 3M products described in the 20-ft (6.1-m) test series report also were used as representative of Class III or Class IV commodities, or both, in several tests. The results of privately sponsored tests on Hallmark products and plastic encapsulated standard commodities also were made available to the committee.

A 25-ft (7.6-m) long test array was used for the majority of the tests for storage over 25 ft (7.6 m). The decision to use such an array was made because it was believed that a fire in racks over 25 ft (7.6 m) high that extended the full length of a 50-ft (15.24-m) long rack could not be considered controlled, particularly as storage heights increased.

One of the purposes of the tests was to determine arrangements of in-rack sprinklers that can be repeated as pile height increases and that provide control of the fire. The tests for storage height of 30 ft (9.1 m) explored the effect of such arrays. Many of these tests, however, produced appreciable fire spread in storage in tiers above the top level of protection within the racks. (In some cases, a total burnout of the top tiers of both the main rack and the target rack occurred.) In the case of the 30-ft (9.1-m) Hallmark Test 134 on the 60-ft

(18.3-m) site, the material in the top tiers of storage burned vigorously, and the fire jumped the aisle above the fourth tier. The fire then burned downward into the south end of the fourth tier. In the test on the floor, a nominal 30-ft (9.1-m) clearance occurred between the top of storage and the ceiling sprinklers, whereas on the platform this clearance was reduced to nominal 10 ft (3.1 m). In most cases, the in-rack sprinklers were effective in controlling fire below the top level of protection within the racks. It has been assumed by the Test Planning Committee that, in an actual case with a clearance of 10 ft (3.1 m) or less above storage, ceiling sprinklers would be expected to control damage above the top level of protection within the racks. Tests have been planned to investigate lesser clearances.

Tests 114 and 128 explore the effect of changing the ignition point from the in-rack standard ignition point to a face ignition location. It should be noted, however, that both of these tests were conducted with 30-ft (9.1-m) clearance from the ceiling sprinklers to the top of storage and, as such, ceiling sprinklers had little effect on the fire in the top two tiers of storage. Firespread in the three lower tiers is essentially the same. A similar change in the firespread where the ignition point is changed was noted in Tests 126 and 127. Once again, 30-ft (9.1-m) clearance occurred between the top of storage and the ceiling sprinklers, and, as such, the ceiling sprinklers had little effect on the face fire. Comparisons of Tests 129, 130, and 131 in the test series for storage height of 50 ft (15.24 m) indicate little effect of point of ignition in the particular configuration tested.

Test 125, when compared with Test 133, indicates no significant difference in result between approved low-profile sprinklers and standard sprinklers in the racks.

C.10 [12.3.1.7] Temperatures in the test column were maintained below 1000°F (538°C) with densities, of roof ceiling sprinklers only, of 0.375 gpm/ft^2 (15.3 mm/min) with 8-ft (2.4-m) aisles and 0.45 gpm/ft^2 (18.3 mm/min) with 4-ft (1.2-m) aisles using the standard commodity.

C.11 [12.3.1.9.1] Test 98 with solid shelves 24 ft (7.3 m) long and 7½ ft (2.3 m) deep at each level produced total destruction of the commodity in the main rack and jumped the aisle. Density was 0.3 gpm/ft^2 (12.2 mm/min) from the ceiling sprinklers only. Test 108 with shelves 24 ft (7.3 m) long and 3½ ft (1.07 m) deep and with a 6-in. (152.4-mm) longitudinal flue space and one level of sprinklers in the rack resulted in damage to most of the commodity in the main rack but did not jump the aisle. Density from ceiling sprinklers was 0.375 gpm/ft^2 (15.3 mm/min), and rack sprinklers discharged at 15 psi (1 bar).

These tests did not yield sufficient information to develop a comprehensive protection standard for solid shelf racks. Items such as increased ceiling density, use of bulkheads, other configurations of sprinklers in racks, and limitation of shelf length and width should be considered.

Where such rack installations exist or are contemplated, the damage potential should be considered, and sound engineering judgment should be used in designing the protection system.

Test 98, with solid shelving obstructing both the longitudinal and transverse flue space, produced unsatisfactory results and indicates a need for sprinklers at each level in such a rack structure.

Test 147 was conducted with ceiling sprinklers only. Density was 0.45 gpm/ft^2 (18.3 mm/min) with a sprinkler spacing of 100 ft^2 (9.29 m^2). A total of 47 sprinklers opened, and 83 percent of the commodity was consumed. The fire jumped both aisles and spread to both ends of the main and target racks. The test was considered unsuccessful.

Test 148 was conducted with ceiling sprinklers and in-rack sprinklers. In-rack sprinklers were provided at each level (top of first, second, and third tiers) and were located in the longitudinal flue. They were directly above each other and 24 ft (7.3 m) on center or 22 ft (6.7 m) on each side of the ignition flue. Ceiling sprinkler discharge density was 0.375 gpm/ft^2 (15.3 mm/min). In-rack sprinkler discharge pressure was 30 psi (2.1 bar). A total of 46 ceiling sprinklers and three in-rack sprinklers opened, and 34 percent of the commodity was consumed. The fire consumed most of the material between the in-rack sprinklers and jumped both aisles.

C.12 [12.3.1.10] Fire tests with open-top containers in the upper tier of storage and a portion of the third tier of storage produced an increase in sprinkler operation from 36 to 41 sprinklers and a more pronounced aisle jump and increase in firespread in the main array. The smooth underside of the containers closely approximates fire behavior of slave pallets.

Installation of in-rack sprinklers or an increase in ceiling sprinkler density should be considered.

C.13 [12.3.1.13] Test 80 was conducted to determine the effect of closing back-to-back longitudinal 6-in. (152.4-mm) flue spaces in conventional pallet racks. Test results indicated fewer sprinklers operating than with the flue space open, and,

Table C.9 Summary of Relationship Between Sprinkler Discharge Density and the Extent of Fire Damage and Sprinkler Operation

Density (gpm/ft^2)	Fire Damage in Test Array: %	Fire Damage in Test Array: ft^2	Sprinkler Operation (165°F) Area (ft^2)
0.30 (ceiling only)	22	395	4500–4800
0.375 (ceiling only)	17	306	1800
0.45 (ceiling only)	9	162	700
0.20 (ceiling only)	28–36	504–648	13,100–14,000
0.20 (sprinklers at ceiling and in racks)	8	144	4100
0.30 (sprinklers at ceiling and in racks)	7	126	700

For SI units: 1 ft = 0.3048 m; °C = 5/9(°F – 32); 1 gpm/ft^2 = 40.746 mm/min.

as such, no minimum back-to-back clearance is necessary if the transverse flue space is kept open.

Tests 145 and 146 were conducted to investigate the influence of longitudinal and transverse flue dimensions in double-row racks without solid shelves. Results were compared with Tests 65 and 66. Flue dimensions in Tests 65, 66, 145, and 146 were 6 in. (152.4 mm), 6 in. (152.4 mm), 3 in. (76.2 mm), and 12 in. (0.3 m), respectively. All other conditions were the same.

In Tests 65 and 66, 45 and 48 sprinklers operated compared with 59 and 58 for Tests 145 and 146, respectively. Fire damage in Tests 145 and 146 was somewhat less than in Tests 65 and 66; 2100 ft^3 (59.51 m^3) and 1800 ft^3 (51 m^3) in Tests 145 and 146, respectively, versus 2300 ft^3 (65.13 m^3) and 2300 ft^3 (65.13 m^3) in Tests 65 and 66, respectively, of combustible material were consumed.

Test results indicate narrow flue spaces of about 3 in. (76.2 mm) allow reasonable passage of sprinkler water down through the racks.

Tests 96 and 107, on multiple-row racks, used 6-in. (152.4-mm) transverse flue spaces. The water demand recommended in the standard is limited to those cases with nominal 6-in. (152.4-mm) transverse flues in vertical alignment.

C.14 [12.3.2.1.1.1] Tests 65 and 66, compared with Test 69, and Test 93, compared with Test 94, indicated a reduction in areas of application of 44.5 percent and 45.5 percent, respectively, with high temperature–rated sprinklers as compared with ordinary temperature–rated sprinklers. Other extensive Factory Mutual tests produced an average reduction of 40 percent. Design curves are based on this area reduction. In constructing the design curves, the high-temperature curves above 3600 ft^2 (334.6 m^2) of application, therefore, represent 40 percent reductions in area of application of the ordinary temperature curves in the 6000-ft^2 to 10,000-ft^2 (557.6-m^2 to 929.41-m^2) range.

Test 84 indicated the number of intermediate temperature–rated sprinklers operating is essentially the same as ordinary temperature–rated sprinklers.

C.15 [12.3.2.1.2.1] Tests were not conducted with aisles wider than 8 ft (2.4 m) or narrower than 4 ft (1.2 m). It is, therefore, not possible to determine whether lower ceiling densities should be used for aisle widths greater than 8 ft (2.4 m) or if higher densities should be used for aisle widths less than 4 ft (1.2 m).

C.16 [12.3.2.4.2.3] In one 20-ft (6.1-m) high test, sprinklers were buried in the flue space 1 ft (0.3 m) above the bottom of the pallet load, and results were satisfactory. Coverage of aisles by in-rack sprinklers is, therefore, not necessary, and distribution across the tops of pallet loads at any level is not necessary for the occupancy classes tested.

C.17 [12.3.2.4.2.6] In all tests with in-rack sprinklers, obstructions measuring 3 in. × 3 ft (76.2 mm × 0.3 m) were introduced on each side of the sprinkler approximately 3 in. (76.2 mm) from the sprinkler to simulate rack structure member obstruction. This obstruction had no effect on sprinkler performance in the 20-ft (6.1-m) high tests.

Tests 103, 104, 105, and 109 in the 30-ft (9.1-m) high test with in-rack sprinklers obstructed by rack uprights produced unsatisfactory results. Tests 113, 114, 115, 117, 118, and 120 in the 30-ft (9.1-m) high test series with in-rack sprinklers located a minimum of 2 ft (0.61 m) from rack uprights produced improved results.

C.18 [12.3.2.4.3] In all except one case, using the standard commodity with one line of sprinklers installed in racks, only two sprinklers opened. In the one exception, two sprinklers opened in the main rack, and two sprinklers opened in the target rack.

C.19 [12.3.2.4.4 and 12.3.3.4.4] Operating pressures were 15 psi (1 bar) on all tests of sprinklers in racks with storage 20 ft (6.1 m) high and 30 psi (2.1 bar) for storage 30 ft (9.1 m) and 50 ft (15.24 m) high.

Tests 112 and 124 were conducted to compare the effect of increasing sprinkler discharge pressure at in-rack sprinklers from 30 psi to 75 psi (2.1 bar to 5.2 bar). With the higher discharge pressure, the fire did not jump the aisle, and damage below the top level of protection within the racks was somewhat better controlled by the higher discharge pressure of the in-rack sprinklers. A pressure of 15 psi (1 bar) was maintained on in-rack sprinklers in the first 30-ft (9.1-m) high tests (Tests 103 and 104). Pressure on in-rack sprinklers in subsequent tests was 30 psi (2.1 bar), except in Test 124, where it was 75 psi (5.2 bar).

C.20 [12.3.2.5.1.1 and 12.3.3.5.1.1] A full-scale test program was conducted with various double-row rack storage arrangements of a cartoned Group A unexpanded plastic commodity at the Factory Mutual Research Corporation (FMRC) test facility. The series of nine tests included several variations, one of which involved the use of the following four distinct shelving arrangements: slatted wood, solid wood, wire mesh, and no shelving. The results of the testing program, specifically Tests 1, 2, 3, and 5, clearly demonstrate the acceptable performance of sprinkler systems protecting storage configurations that involve the use of slated shelving as described in 12.3.2.5.1.1 and 12.3.3.5.1.1. As a result of the test program, Factory Mutual has amended FM Loss Prevention Data Sheet 8-9 to allow slatted shelving to be protected in the same manner as an open rack arrangement.

Complete details of the test program are documented in the FMRC technical report FMRC J. I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Storage Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers."

C.21 [12.3.3.1.1] In the RSP rack storage test series as well as the stored plastics program palletized test series, compartmented 16-oz (0.47-L) polystyrene jars were found to produce significantly higher protection requirements than the same commodity in a nested configuration. Polystyrene glasses and expanded polystyrene plates were comparable to the nested jars.

Different storage configurations within cartons or different products of the same basic plastic might, therefore, require reduced protection requirements.

In Test RSP-7, with nominal 15-ft (4.6-m) high storage with compartmented jars, a 0.6 gpm/ft^2 (24.5 mm/min) density, 8-ft (2.4-m) aisles, and a 10-ft (3.1-m) ceiling clearance, 29 sprinklers opened. In Tests RSP-4 with polystyrene glasses, RSP-5 with expanded polystyrene plates, and RSP-16 with nested polystyrene jars all stored at nominal 15-ft (4.6-m) height, 10-ft (3.1-m) ceiling clearance, 8-ft (2.4-m) aisles, and 0.6 gpm/ft^2 (24.5 mm/min) density, only four sprinklers opened.

However, Test RSP-11, with expanded polystyrene plates and 6-ft (1.8-m) aisles, demonstrated an increase in the number of operating sprinklers to 29. Test RSP-10 with expanded polystyrene plates, nominally 15 ft (4.6 m) high with a 10-ft (3.1-m) clearance and 8-ft (2.4-m) aisles, but protected only by

0.45 gpm/ft^2 (18.3 mm/min) density, opened 46 sprinklers and burned 100 percent of the plastic commodity.

At a nominal 20-ft (6.1-m) storage height with 8-ft (2.4-m) aisles, a 3-ft (0.9-m) ceiling clearance, and a 0.6 gpm/ft^2 (24.5 mm/min) density opened four sprinklers with polystyrene glasses in Test RSP-2 and 11 sprinklers with expanded polystyrene plates in Test RSP-6. In Test RSP-8, however, with the ceiling clearance increased to 10 ft (3.1 m) and other variables held constant, 51 sprinklers opened, and 100 percent of the plastic commodity burned.

Test RSP-3 with polystyrene glasses at a nominal height of 25 ft (7.6 m) with a 3-ft (0.9-m) ceiling clearance, 8-ft (2.4-m) aisles, and 0.6 gpm/ft^2 (24.5 mm/min) ceiling sprinkler density in combination with one level of in-rack sprinklers, resulted in four ceiling sprinklers and two in-rack sprinklers operating. Test RSP-9, with the same configuration but with polystyrene plates, opened 12 ceiling sprinklers and three in-rack sprinklers.

No tests were conducted with compartmented polystyrene jars at storage heights in excess of a nominal 15 ft (4.6 m) as a part of this program.

C.22 [12.3.3.1.5] The protection of Group A plastics by extra large orifice (ELO) sprinklers designed to provide 0.6 gpm/ft^2/2000 ft^2 (24.5 mm/min/186 m^2) or 0.45 gpm/ft^2/2000 ft^2 (18.3 mm/min/186 m^2) without the installation of in-rack sprinklers was developed from full-scale testing conducted with various double-row rack storage arrangements of a cartoned Group A unexpanded plastic commodity at the Factory Mutual Research Corporation (FMRC) test facility. The results of this test program are documented in the FMRC technical report, FMRC J.I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Stored Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers." The test program was initiated to address the fire protection issues presented by warehouse-type retail stores with regard to the display and storage of Group A plastic commodities including, but not limited to, acrylonitrile-butadiene-styrene copolymer (ABS) piping, polyvinyl chloride (PVC) hose and hose racks, tool boxes, polypropylene trash and storage containers, and patio furniture. Tests 1 and 2 of this series included protection of the Group A plastic commodity stored to 20 ft (6.1 m) under a 27-ft (8.2-m) ceiling by a design density of 0.6 gpm/ft^2 (24.5 mm/min) utilizing ELO sprinklers. The results of the testing program clearly demonstrate the acceptable performance of sprinkler systems that protect storage configurations involving Group A plastics up to 20 ft (6.1 m) in height under a 27-ft (8.2-m) ceiling where using ELO sprinklers to deliver a design density of 0.6 gpm/ft^2 (24.5 mm/min) and Group A plastics up to 14 ft (4.3 m) in height under a 22-ft (6.7-m) ceiling where using ELO sprinklers to deliver a design density of 0.45 gpm/ft^2 (18.3 mm/min). The tabulation of the pertinent tests shown in Table C.22 demonstrates acceptable performance.

Table C.22 Summary of Test Results for Plastic Commodities Using ⅝-in. (15.9-mm) Orifice Sprinklers

	Date of Test						
Test Parameters	**8/20/93**	**8/25/93**	**9/2/93**	**10/7/93**	**2/17/94**	**2/25/94**	**4/27/94**
Type of shelving	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Slatted wood	Wire mesh
Other conditions/ inclusions	—	—	—	—	Draft curtains	Draft curtains	—
Storage height (ft-in.)	19-11	19-11	15-4	15-4	19-11	19-11	13-11
Number of tiers	6[a]	6[a]	5[b]	5[b]	6[a]	6[b]	3
Clearance to ceiling/sprinklers (ft-in.)	6-10/6-3	6-10/6-3	11-5/10-10	11-5/10-10	6-10/6-3	6-10/6-3	8-4/7-9
Longitudinal/ transverse flues (in.)	6/6 to 7½	6/6 to 7½	6/6 to 7	6/6 to 7½	6/6 to 7½	6/6 to 7½	6/3[c]
Aisle width (ft)	7½	7½	7½	7½	7½	7½	7½
Ignition centered below (number of sprinklers)	2	2	1	1	2	2	1
Sprinkler orifice size (in.)	0.64	0.64	0.64	0.64	0.64	0.64	0.64
Sprinkler temperature rating (°F)	165	286	286	165	165	286	286
Sprinkler RTI (ft-sec)$^{1/2}$	300	300	300	300	300	300	300
Sprinkler spacing (ft × ft)	8 × 10	8 × 10	8 × 10	8 × 10	8 × 10	8 × 10	10 × 10
Sprinkler identification	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231	ELO-231
Constant water pressure (psi)	19	19	19	19	19	19	15.5
Minimum density (gpm/ft^2)	0.6	0.6	0.6	0.6	0.6	0.6	0.45

Table C.22 *Continued*

Test Results	Date of Test						
	8/20/93	8/25/93	9/2/93	10/7/93	2/17/94	2/25/94	4/27/94
First sprinkler operation (min:sec)	2:03	2:25	1:12	0:44	1:25	0:52	0:49
Last sprinkler operation (min:sec)	2:12	15:19	6:34	7:34	15:54	14:08	10:58
Total sprinklers opened	4	9	7	13	35	18	12
Total sprinkler discharge (gpm)	205	450	363	613	1651	945	600
Average discharge per sprinkler (gpm)	51	50	52	47	47	52	50
Peak/maximum 1-min average gas temperature (°F)	1107/566	1412/868	965/308	662/184	1575/883	1162/767	1464/895
Peak/maximum 1-min average steel temperature (°F)	185/172	197/196	233/232	146/145	226/225	255/254	502/500
Peak/maximum 1-min average plume velocity (ft/sec)	27/15	25/18	18/15[d]	14/10[d]	26/23	20/18[d]	33/20
Peak/maximum 1-min heat flux (Btu/ft^2/sec)	0.6/0.5	2.0/1.9	2.8/2.5	1.1/0.8	1.0/0.9	4.8/3.0	1.6/1.4
Aisle jump, east/west target ignition (min:sec)	None	8:24/None	5:35/10:10	None	None	[e]/8:18	[e]/None
Equivalent number of pallet loads consumed	3	9	6	5	12	13	12
Test duration (min)	30	30	30	30	30	30	30
Results acceptable	Yes	Yes	Yes	Yes	No[f]	No[g]	Yes

For SI units, 1 ft = 0.305 m; 1 in. = 25.4 mm; °F = (1.8 × °C) + 32; °C = (°F – 32)/1.8; 1 psi = 0.069 bar; 1 gpm = 3.8 L/min; 1 ft/sec = 0.31 m/sec; 1 gpm/ft^2 = 40.746 mm/min.

[a] Main (ignition) racks divided into five or six tiers; bottom tiers each approximately 2 ft (0.6 m) high and upper tiers each about 5 ft (1.5 m) high; wood shelving below commodity at second through fifth tiers.

[b] Main (ignition) racks divided into five or six tiers; bottom tiers each approximately 2 ft (0.6 m) high and upper tiers each about 5 ft (1.5 m) high; wood shelving below commodity at second through fifth tiers; wire mesh shelving below commodity at sixth tier or below fifth (top) tier commodity.

[c] Transverse flues spaced 8 ft (2.4 m) apart [versus 3½ ft (1.1 m) apart in all other tests].

[d] Instrumentation located 5 ft (1.5 m) north of ignition.

[e] Minor surface damage to cartons.

[f] High water demand.

[g] Excessive firespread; marginally high water demand.

C.23 [12.3.4.1.1] The recommended use of ordinary temperature–rated sprinklers at ceiling for storage higher than 25 ft (7.6 m) was determined by the results of fire test data. A test with high temperature–rated sprinklers and 0.45 gpm/ft^2 (18.3 mm/min) density resulted in fire damage in the two top tiers just within acceptable limits, with three ceiling sprinklers operating. A test with 0.45 gpm/ft^2 (18.3 mm/min) density and ordinary temperature–rated sprinklers produced a dramatic reduction in fire damage with four ceiling sprinklers operating.

The four ordinary temperature-rated ceiling sprinklers operated before the first of the three high temperature–rated ceiling sprinklers. In both tests, two in-rack sprinklers at two levels operated at approximately the same time. The high temperature–rated sprinklers were at all times fighting a larger fire with less water than the ordinary temperature–rated ceiling sprinklers.

Tests 115 and 119 compare ceiling sprinkler density of 0.3 gpm/ft^2 (12.2 mm/min) with 0.45 gpm/ft^2 (18.3 mm/min). Damage patterns coupled with the number of boxes damaged in the main rack suggest that the increase in density produces improved control, particularly in the area above the top tier of in-rack sprinklers.

Tests 119 and 122 compare ceiling sprinkler temperature ratings of 286°F (141°C) and 165°F (74°C). A review of the number of boxes damaged and the firespread patterns indicates that the use of ordinary temperature–rated ceiling sprinklers on a rack configuration that incorporates in-rack sprinklers dramatically reduces the amount of firespread. Considering that in-rack sprinklers in the tests for storage over 25 ft (7.6 m) operated prior to ceiling sprinklers, it would seem that the installation of in-rack sprinklers converts an otherwise rapidly developing fire, from the standpoint of ceiling sprinklers, to a slower developing fire with a lower rate of heat release.

In the 20-ft (6.1-m) high test series, ceiling sprinklers operated before in-rack sprinklers. In the 30-ft (9.1-m) high series, ceiling sprinklers operated after in-rack sprinklers. The 50-ft (15.24-m) high test did not operate ceiling sprinklers. Ceiling sprinklers would, however, be needed if fire occurred in upper levels.

The results of these tests indicate the effect of in-rack sprinklers on storage higher than 25 ft (7.6 m). From the ceiling sprinkler operation standpoint, a fire with an expected high heat release rate was converted to a fire with a much lower heat release rate.

Since the fires developed slowly and opened sprinklers at two levels in the racks, only a few ceiling sprinklers were needed to establish control. Thus, the sprinkler operating area does not vary with height for storage over 25 ft (7.6 m) or for changes in sprinkler temperature rating and density.

All tests with sprinklers in racks were conducted using nominal ½-in. (12.7-mm) orifice size sprinklers of ordinary temperature.

Annex D Sprinkler System Information from the 1997 Edition of the *Life Safety Code*

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Introduction. This annex is provided as an aid to the user of NFPA 13 by identifying those portions of the 1997 edition of *101, Life Safety Code,* that pertain to sprinkler system design and installation. It is not intended that this annex provide complete information regarding all aspects of fire protection addressed by NFPA *101.* It is important to note that this information was not copied from NFPA *101* using NFPA's extract policy and is not intended to be a part of the requirements of NFPA 13. While the 1997 edition of the *Life Safety Code* was the most current at the time of the publication of the 1999 edition of NFPA 13, a 2000 edition of the *Life Safety Code* is in preparation.

D.2 Definitions. See NFPA *101, Life Safety Code,* for terms not defined in Chapter 3.

D.3 Atriums. Glass walls and inoperable windows shall be permitted in lieu of the fire barriers where automatic sprinklers are spaced 6 ft (1.8 m) apart or less along both sides of the glass wall and inoperable windows, not more than 1 ft (0.3 m) from the glass, and with the automatic sprinklers located so that the entire surface of the glass is wet upon operation of the sprinklers. The glass shall be tempered, wired, or laminated glass held in place by a gasket system that permits the glass framing system to deflect without breaking (loading) the glass before the sprinklers operate. Automatic sprinklers shall not be required on the atrium side of the glass wall and inoperable windows where there is no walkway or other floor area on the atrium side above the main floor level. Doors in such walls shall be glass or other material that will resist the passage of smoke. Doors shall be self-closing or automatic-closing upon detection of smoke. [***101***:6.2.4.6, Exception No. 2 to (a)]

D.4 Connection to Domestic Water Supply. Sprinkler piping serving not more than six sprinklers for any isolated hazardous area shall be permitted to be connected directly to a domestic water supply system having a capacity sufficient to provide 0.15 gpm/sq ft (6.1 L/min/sq m) of floor area throughout the entire enclosed area. An indicating shut-off valve shall be installed in an accessible location between the sprinklers and the connection to the domestic water supply. [***101***:7.7.1.2]

D.5 Supervision. [***101***: 7.7.2]

D.5.1 Supervisory Signals. Where supervised, automatic sprinkler systems are required by another section of NFPA *101,* supervisory attachments shall be installed and monitored for integrity in accordance with *NFPA 72, National Fire Alarm Code,* and a distinctive supervisory signal shall be provided to indicate a condition that would impair the satisfactory operation of the sprinkler system. This shall include, but not be limited to, monitoring of control valves, fire pump power supplies and running conditions, water tank levels and temperatures, pressure of tanks, and air pressure on dry-pipe valves. Supervisory signals shall sound and shall be displayed either at a location within the protected building that is constantly attended by qualified personnel or at an approved, remotely located receiving facility. [***101***:7.7.2.1]

D.5.2 Alarm Signal Transmission. Where supervision of automatic sprinkler systems is provided in accordance with another provision of NFPA *101,* waterflow alarms shall be transmitted to an approved, proprietary alarm receiving facility, a remote station, a central station, or the fire department. Such connection shall be installed in accordance with 7.6.1.4 of NFPA *101.* [***101***:7.7.2.2]

D.6 Stages.

D.6.1 Sprinklers shall not be required for stages 1000 sq ft (93 sq m) or less in area and 50 ft (15 m) or less in height where curtains, scenery, or other combustible hangings are not retractable vertically. Combustible hangings shall be limited to a single main curtain, borders, legs, and a single backdrop. [***101***:8.4.5.10, Exception No. 1]

D.6.2 Sprinklers shall not be required under stage areas less than 4 ft (1.2 m) in clear height used exclusively for chair or table storage and lined on the inside with ⅝-in. (1.6-cm) Type X gypsum wallboard or the approved equivalent. [***101***:8.4.5.10, Exception No. 2]

D.7 Exhibition Booths. The following shall be protected by automatic extinguishing systems:

(1) Single-level exhibit booths greater than 300 sq ft (27.9 sq m) and covered with a ceiling.
(2) Throughout each level of multilevel exhibit booths, including the uppermost level if the uppermost level is covered with a ceiling.
(3) A single exhibit or group of exhibits with ceilings that do not require sprinklers shall be separated by a minimum of 10 ft (3 m) where the aggregate ceiling exceeds 300 sq ft (27.9 sq m).

The water supply and piping for the sprinkler system shall be permitted to be of approved temporary means taken from an existing domestic water supply, an existing standpipe system, or an existing sprinkler system.

Exception No. 1: Ceilings that are constructed of open grate design or listed dropout ceilings in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, shall not be considered ceilings within the context of this section.

Exception No. 2: Vehicles, boats, and similar exhibited products having over 100 sq ft (9.3 sq m) of roofed area shall be provided with smoke detectors acceptable to the authority having jurisdiction.

Exception No. 3: Where fire protection of multilevel exhibit booths is consistent with the criteria developed through a life safety evaluation of the exhibition hall in accordance with 8.4.1 of NFPA 101, subject to approval of the authority having jurisdiction. (See A.8.2.3.2 of NFPA 101.)

*[**101:**8.7.5.3.7]*

D.8 Proscenium Curtain. The proscenium opening of every legitimate stage shall be provided with a curtain constructed and mounted so as to intercept hot gases, flames, and smoke and to prevent flame from a fire on the stage from becoming visible from the auditorium side for a 5-min period where the curtain is of asbestos. Other materials shall be permitted if they have passed a 30-min fire test in a small scale 3 ft × 3 ft (0.9 m × 0.9 m) furnace with the sample mounted in the horizontal plane at the top of the furnace and subjected to the standard time-temperature curve.

The curtain shall be automatic-closing without the use of applied power.

All proscenium curtains shall be in the closed position except during performances, rehearsals, or similar activities.

Exception No. 1: In lieu of the protection required herein, all the following shall be provided:

(1) *A noncombustible opaque fabric curtain shall be arranged so that it will close automatically; and*
(2) *An automatic, fixed waterspray deluge system shall be located on the auditorium side of the proscenium opening and shall be arranged so that the entire face of the curtain will be wetted. The system shall be activated by combination of rate-of-rise and fixed-temperature detectors located on the ceiling of the stage. Detectors shall be spaced in accordance with their listing. The water supply shall be controlled by a deluge valve and shall be sufficient to keep the curtain completely wet for 30 min or until the valve is closed by fire department personnel; and*
(3) *The curtain shall be automatically operated in case of fire by a combination of rate-of-rise and fixed-temperature detectors that also activates the deluge spray system. Stage sprinklers and vents shall be automatically operated by fusible elements in case of fire; and*
(4) *Operation of the stage sprinkler system or spray deluge valve shall automatically activate the emergency ventilating system and close the curtain; and*
(5) *The curtain, vents, and spray deluge system valve shall also be capable of manual operation.*

Exception No. 2: Proscenium fire curtains or water curtains complying with 8.4.5.7 of NFPA 101.

[***101:*** 9.4.5.7]

D.9 Listed quick response or listed residential sprinklers shall be used throughout smoke compartments containing patient sleeping rooms. [***101:***12.3.5.2]

The requirements for use of quick response sprinklers intends that quick response sprinklers be the predominant type of sprinkler installed in the smoke compartment. It is recognized, however, that quick response sprinklers may not be approved for installation in all areas such as those where NFPA 13, *Standard for the Installation of Sprinkler Systems,* requires sprinklers of the intermediate- or high-temperature classification. It is not the intent of the 12-3.5.2 of NFPA *101* requirements to prohibit the use of standard sprinklers in limited areas of a smoke compartment where intermediate- or high-temperature sprinklers are required.

Where the installation of quick response sprinklers is impracticable in patient sleeping room areas, appropriate equivalent protection features acceptable to the authority having jurisdiction should be provided. It is recognized that the use of quick response sprinklers may be limited in facilities housing certain types of patients, or due to the installation limitations of quick response sprinklers. [***101:***A.12.3.5.2]

D.10 Where an automatic sprinkler system is installed, either for total or partial building coverage, the system shall be installed in accordance with Section 7.7 of NFPA *101.* In buildings up to and including four stories in height, systems installed in accordance with NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height,* shall be permitted.

Exception No. 1: In individual dwelling units, sprinkler installation shall not be required in closets not over 12 sq ft (1.1 sq m). Closets that contain equipment such as washers, dryers, furnaces, or water heaters shall be sprinklered regardless of size.

Exception No. 2: The draft stop and closely spaced sprinkler requirements of NFPA 13, Standard for the Installation of Sprinkler Systems, shall not be required for convenience openings complying with 6.2.4.8 of NFPA 101 where the convenience opening is within the dwelling unit.

*[**101:**18.3.5.1]*

Annex E Informational References

E.1 Referenced Publications. The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not part of the requirements of this document unless also listed in Chapter 2.

E.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13E, *Recommended Practice for Fire Department Operations in Properties Protected by Sprinkler and Standpipe Systems,* 2000 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height,* 2002 edition.

NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* 2000 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2001 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 1999 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 1999 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 1998 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.

NFPA 36, *Standard for Solvent Extraction Plants,* 1997 edition.

NFPA 72®, National Fire Alarm Code®, 2002 edition.

NFPA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures,* 2001 edition.

NFPA *101®, Life Safety Code®,* 2000 edition.

NFPA 220, *Standard on Types of Building Construction,* 1999 edition.

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants,* 2002 edition.

NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves,* 2000 edition.

NFPA 409, *Standard on Aircraft Hangars,* 2001 edition.

NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations,* 2000 edition.

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants,* 2000 edition.

E.1.2 Other Publications.

E.1.2.1 ACPA Publication. American Concrete Pipe Association, 222 W. Las Collinas Boulevard, Suite 641, Irving, TX 75039.

Concrete Pipe Handbook.

E.1.2.2 ASCE Publication. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.

ASCE 19, *Standard Guidelines for the Structural Applications of Steel Cables for Buildings,* 1996.

E.1.2.3 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME B16.1, *Cast-Iron Pipe Flanges and Flanged Fittings,* 1989.

ASME A17.1, *Safety Code for Elevators and Escalators,* 1996.

ASME B1.20.1, *Pipe Threads, General Purpose (Inch),* 1983.

E.1.2.4 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 126, *Standard Specification for Gray Iron Casting for Valves, Flanges, and Pipe Fittings,* 1995.

ASTM A 135, *Standard Specification for Electric-Resistance-Welded Steel Pipe,* 1997.

ASTM A 197, *Standard Specification for Cupola Malleable Iron,* 1987.

ASTM A 307, *Standard Specification for Carbon Steel Bolts and Studs,* 1997.

ASTM A 603, *Standard Specification for Zinc-Coated Steel Structural Wire Rope,* 1998.

ASTM C 296, *Standard Specification for Asbestos-Cement Pressure Pipe,* 1988.

ASTM D 3309, *Standard Specification for Polybutylene (PB) Plastic and Hot- and Cold-Water Distribution Systems,* 1996.

ASTM E 8, *Structural Test Method for Tension Testing of Metallic Materials,* 2001.

ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* 1998.

ASTM F 437, *Standard Specification for Threaded Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80,* 1996.

ASTM F 438, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 40,* 1997.

ASTM F 439, *Standard Specification for Socket-Type Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80,* 1997.

ASTM F 442, *Standard Specification for Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe (SDR-PR),* 1997.

E.1.2.5 AWWA Publications. American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

AWWA C104, *Cement Mortar Lining for Ductile Iron Pipe and Fittings for Water,* 1995.

AWWA C105, *Polyethylene Encasement for Ductile Iron Pipe Systems,* 1993.

AWWA C110, *Ductile Iron and Gray Iron Fittings, 3-in. Through 48-in., for Water and Other Liquids,* 1993.

AWWA C111, *Rubber-Gasket Joints for Ductile Iron Pressure Pipe and Fittings,* 1990.

AWWA C115, *Flanged Ductile Iron Pipe with Ductile Iron or Gray Iron Threaded Flanges,* 1994.

AWWA C150, *Thickness Design of Ductile Iron Pipe,* 1996.

AWWA C151, *Ductile Iron Pipe, Centrifugally Cast for Water,* 1996.

AWWA C153, *Ductile Iron Compact Fittings, 3 in. through 24 in. and 54 in. through 64 in. for Water Service,* 1994.

AWWA C203, *Coal-Tar Protective Coatings and Linings for Steel Water Pipelines Enamel and Tape — Hot Applied,* 1997.

AWWA C205, *Cement-Mortar Protective Lining and Coating for Steel Water Pipe 4 in. and Larger — Shop Applied,* 1995.

AWWA C206, *Field Welding of Steel Water Pipe,* 1997.

AWWA C208, *Dimensions for Fabricated Steel Water Pipe Fittings,* 1996.

AWWA C300, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids,* 1997.

AWWA C301, *Prestressed Concrete Pressure Pipe, Steel-Cylinder Type, for Water and Other Liquids,* 1992.

AWWA C302, *Reinforced Concrete Pressure Pipe, Non-Cylinder Type, for Water and Other Liquids,* 1995.

AWWA C303, *Reinforced Concrete Pressure Pipe, Steel-Cylinder Type, Pretensioned, for Water and Other Liquids,* 1995.

AWWA C400, *Standard for Asbestos-Cement Distribution Pipe, 4 in. Through 16 in., for Water and Other Liquids,* 1993.

AWWA C401, *Standard Practice for the Selection of Asbestos-Cement Water Pipe,* 1993.

AWWA C600, *Standard for the Installation of Ductile-Iron Water Mains and Their Appurtenances,* 1993.

AWWA C602, *Cement-Mortar Lining of Water Pipe Lines 4 in. and Larger — in Place,* 1995.

AWWA C603, *Standard for the Installation of Asbestos-Cement Water Pipe,* 1996.

AWWA C606, *Grooved and Shouldered Joints,* 1997.

AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe, 4 in. Through 12 in., for Water and Other Liquids,* 1997.

AWWA M11, *A Guide for Steel Pipe Design and Installation,* 3rd edition, 1989.

AWWA M14, *Recommended Practice for Backflow Prevention and Cross Connection Control,* 2nd edition, 1990.

AWWA M41, *Ductile Iron and Pipe Fittings.*

E.1.2.6 DIRPA Publication. Ductile Iron Pipe Research Association, 245 Riverchase Parkway, East, Suite 0, Birmingham, AL 35244.

Installation Guide for Ductile Iron Pipe.

Thrust Restraint Design for Ductile Iron Pipe.

E.1.2.7 EPRI Publication. EPRI, 3412 Hillview Avenue, Palo Alto, CA 94304.

1843-2, "Turbine Generator Fire Protection by Sprinkler System," July 1985.

E.1.2.8 FMRC Publication. Factory Mutual Research Corporation, 1151 Boston-Providence Turnpike, Norwood, MA 02061.

FMRC J. I. 0X1R0.RR, "Large-Scale Fire Tests of Rack Storage Group A Plastics in Retail Operation Scenarios Protected by Extra Large Orifice (ELO) Sprinklers."

E.1.2.9 IMO Publication. International Maritime Organization, 4 Albert Embankment, London, SEI 7SR, United Kingdom.

International Convention for the Safety of Life at Sea, 1974 (SOLAS 74), as amended, regulations II-2/3 and II-2/26.

E.1.2.10 SNAME Publication. Society of Naval Architects and Marine Engineers, 601 Pavonia Ave., Suite 400, Jersey City, NJ 07306.

Technical Research Bulletin 2-21, "Aluminum Fire Protection Guidelines."

E.1.2.11 UL Publication. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

"Commodity Hazard Comparison of Expanded Plastic in Portable Bins and Racking," Project 99NK29106, NC4004, September 8, 2000.

"Technical Report of Fire Testing of Automotive Parts in Portable Storage Racking," Project 99NK29106, NC4004, January 5, 2001.

E.1.2.12 Uni-Bell Plastic Pipe Publication. Uni-Bell Plastic Pipe Association, 2655 Villa Creek Drive, Suite 155, Dallas, TX 75234.

Handbook of PVC Pipe.

E.1.2.13 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 46, *Code of Federal Regulations,* Part 72.05-5.

U.S. Federal Standard No. 66C, *Standard for Steel Chemical Composition and Harden Ability,* April 18, 1967, change notice No. 2, April 16, 1970.

E.2 Informational References. (Reserved)

E.3 References for Extracts. The following documents are listed here to provide reference information, including title and edition, for extracts given throughout this standard as indicated by a reference in brackets [ ] following a section or paragraph. These documents are not a part of the requirements of this document unless also listed in Chapter 2 for other reasons.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 2000 edition.

NFPA 36, *Standard for Solvent Extraction Plants,* 2001 edition.

NFPA 40, *Standard for the Storage and Handling of Cellulose Nitrate Film,* 2001 edition.

NFPA 42, *Code for the Storage of Pyroxylin Plastic,* 2002 edition.

NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals,* 2000 edition.

NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Other Hot Work,* 1999 edition.

NFPA 51A, *Standard for Acetylene Cylinder Charging Plants,* 2001 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed and Liquefied Gases in Portable Cylinders,* 1998 edition.

NFPA 59, *Utility LP-Gas Plant Code,* 2001 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2001 edition.

NFPA 75, *Standard for the Protection of Electronic and Computer/Data Processing Equipment,* 1999 edition.

NFPA 82, *Standard on Incinerators and Waste and Linen Handling Systems and Equipment,* 1999 edition.

NFPA 86C, *Standard for Industrial Furnaces Using a Special Processing Atmosphere,* 1999 edition.

NFPA 99, *Standard for Health Care Facilities,* 2002 edition.

NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems,* 2000 edition.

NFPA 150, *Standard on Fire Safety in Racetrack Stables,* 2000 edition.

NFPA 214, *Standard on Water-Cooling Towers,* 2000 edition.

NFPA 307, *Standard for the Construction of Marine Terminals, Piers, and Wharves,* 2000 edition.

NFPA 318, *Standard for the Protection of Semiconductor Fabrication Facilities,* 2002 edition.

NFPA 415, *Standard on Airport Terminal Buildings, Fueling Ramp Drainage, and Loading Walkways,* 2002 edition.

NFPA 423, *Standard for Construction and Protection of Aircraft Engine Test Facilities,* 1999 edition.

NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers,* 2000 edition.

NFPA 432, *Code for the Storage of Organic Peroxide Formulations,* 2002 edition.

NFPA 804, *Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants,* 2001 edition.

NFPA 805, *Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants,* 2001 edition.

NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations,* 2000 edition.

NFPA 851, *Recommended Practice for Fire Protection for Hydroelectric Generating Plants,* 2000 edition.

NFPA 909, *Code for the Protection of Cultural Resources,* 2001 edition.

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Tentative Interim Amendment

NFPA 13

Standard for the Installation of Sprinkler Systems

2002 Edition

Reference: Various
TIA 02-1 (NFPA 13)
(SC 03-7-8/Log No. 748)

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 edition. The TIA was processed by the Automatic Sprinkler Systems Committee, and was issued by the Standards Council on July 17, 2003, with an effective date of August 6, 2003.

A Tentative Interim Amendment is tentative because it has not been processed through the entire standards-making procedures. It is interim because it is effective only between editions of the standard. A TIA automatically becomes a proposal of the proponent for the next edition of the standard; as such, it then is subject to all of the procedures of the standards-making process.

1. Reword Sections 9.3.5.6, 9.3.5.6.1, A.9.3.5.6.1, 9.3.5.6.2 and 9.3.5.7 to read as follows:

9.3.5.6* Horizontal Seismic Loads.

9.3.5.6.1 The horizontal seismic load for the braces shall be determined as required by the authority having jurisdiction. The weight of the system being braced (Wp) shall be taken as 1.15 times the weight of the water-filled piping. [See A.9.3.5.6.1.]

A 9.3.5.6.1 The several factors used in the computation of the horizontal seismic load should be available from the project architect or structural engineer. Sprinkler systems are emergency systems and as such should be designed for an Importance Factor (Ip) of 1.5. Seismic load equations allow the reduction of the seismic force by a Component Response Modification Factor (Rp), that reflects the ductility of the system; systems where braced piping are primarily joined by threaded fittings should be considered less ductile than systems where braced piping are joined by welded or mechanical type fittings. While research coninues in understanding the performance of sprinkler piping under seismic loads, the good performance of properly braced sprinkler piping in past earthquakes suggests that properly braced systems perform with high ductility, which currently relates to an Rp factor of 3.5.

9.3.5.6.2 Where the authority having jurisdiction does not specify the horizontal seismic load, the horizontal seismic force acting on the braces shall be determined based on a horizontal force of Fp= 0.5 Wp, where Fp is the horizontal force factor and Wp is 1.15 times the weight of the water filled piping.

9.3.5.7 Where the horizontal seismic loads used exceed 0.5 Wp and the brace angle is less than 45 degrees from vertical or where the horizontal seismic load exceeds 1.0 Wp and the brace angle is less than 60 degrees from vertical, the braces shall be arranged to resist the net vertical reaction produced by the horizontal load.

2. Replace Figure 9.3.5.9.1 and its associated tables and modify Section A.9.3.5.9 to read as follows:

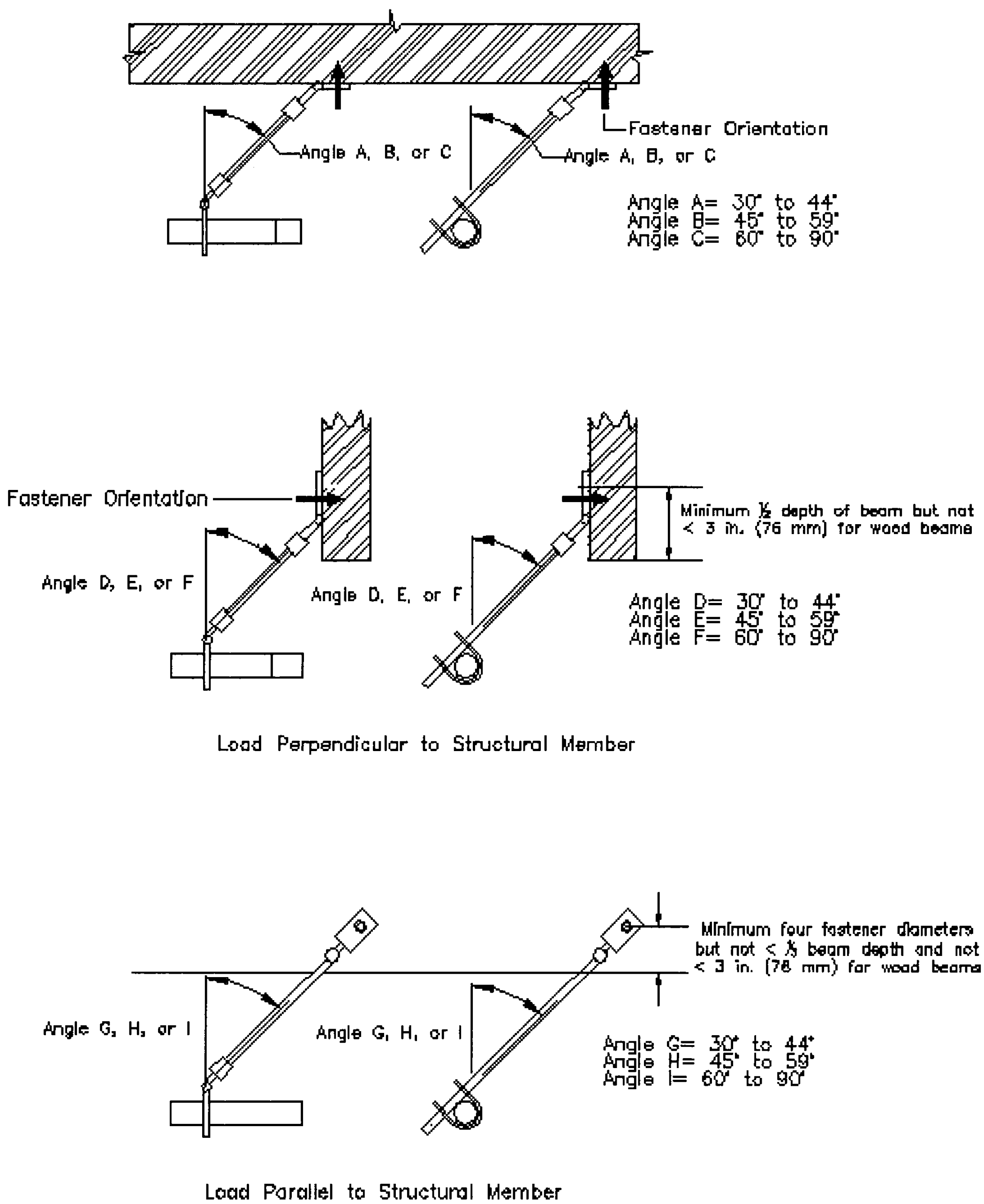

Figure 9.3.5.9.1 Maximum Loads for Various Types of Structure and Maximum Loads for Various Types of Fasteners to Structure.

Through Bolts in Sawn Lumber or Glue Laminated Timbers (Load Perpendicular to Grain)																												
		Bolt Diameter (in.)																										
		1/2									5/8									3/4								
Length of Bolt in Timber (in.)		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
	1 1/2	115	165	200	135	230	395	130	215	310	135	190	235	155	270	460	155	255	380	155	220	270	180	310	530	170	300	450
	2 1/2	140	200	240	160	280	480	165	275	410	160	225	280	185	320	550	190	320	495	180	255	310	205	360	615	215	365	575
	3 1/2	175	250	305	200	350	600	200	330	485	200	285	345	230	400	685	235	405	635	220	310	380	255	440	755	260	455	730
	5 1/2	*	*	*	*	*	*	*	*	*	280	395	485	325	560	960	315	515	735	310	440	535	360	620	1065	360	610	925

Lag Screws and Lag Bolts in Wood (Load Perpendicular to Grain - Holes Predrilled Using Good Practice)																												
		Lag Bolt Diameter (in.)																										
		3/8									1/2									5/8								
Length Under Head (in.)		A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
	3 1/2	165	190	200	170	220	310	80	120	170	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	4 1/2	180	200	200	175	235	350	80	120	170	300	355	380	315	400	550	145	230	325	*	*	*	*	*	*	*	*	*
	5 1/2	190	200	200	175	245	380	80	120	170	320	370	380	320	420	610	145	230	325	435	525	555	425	550	775	195	320	460
	6 1/2	195	205	200	175	250	400	80	120	170	340	375	380	325	435	650	145	230	325	465	540	555	430	570	840	195	320	460

Note: Wood fastener maximum capacity values are based on 2001 National Design Specifications (NDS) for wood with a specific gravity of 0.35. Values for other types of wood can obtained by multiplying the above values by the following factors:

Specific Gravity of Wood	Multiplier
0.36 thru 0.49	1.17
0.50 thru 0.65	1.25
0.66 thru 0.73	1.50

Wedge Anchors in Normal Weight Concrete										
Diameter (in)	Embedment (in)	A	B	C	D	E	F	G	H	I
3/8	3	120	290	615	540	465	410	385	545	665
1/2	4	210	510	1085	955	825	720	690	975	1195
5/8	5	300	730	1550	1415	1200	1035	1085	1530	1875
3/4	6	385	945	2005	1920	1600	1335	1800	2545	3120

Wedge Anchors in Lightweight Concrete Filled Metal Decking										
Diameter (in)	Embedment (in)	A	B	C	D	E	F	G	H	I
3/8	1 1/4	75	175	375	-	-	-	-	-	-
1/2	2 1/4	100	245	520	-	-	-	-	-	-
5/8	2 1/4	150	370	780	-	-	-	-	-	-
3/4	3 1/4	160	390	825	-	-	-	-	-	-

Undercut Anchors in Normal Weight Concrete										
Diameter (mm)	Embedment (in)	A	B	C	D	E	F	G	H	I
M10	4	305	745	1125	1165	1105	1050	650	920	1125
M12	5	460	1130	1645	1740	1665	1595	950	1345	1645
M16	7 1/2	825	2020	2930	3110	2980	2860	1695	2395	2930

Note: These are minimum values to be used for a generic anchors in normal weight concrete slabs, lightweight concrete metal filled decking and a table for undercut anchors in normal weight concrete. Anchors with special listings shall be installed in accordance with their requirements.

Connections to Steel (Values Assume Bolt Perpendicular to Mounting Surface)																	
Diameter of Unfinished Steel Bolt (in.)																	
1/4									3/8								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
400	500	600	300	500	650	325	458	565	900	1200	1400	800	1200	1550	735	1035	1278
Diameter of Unfinished Steel Bolt (in.)																	
1/2									5/8								
A	B	C	D	E	F	G	H	I	A	B	C	D	E	F	G	H	I
1600	2050	2550	1450	2050	2850	1300	1830	2260	2500	3300	3950	2250	3300	4400	2045	2880	3557

A.9.3.5.9 Current fasteners for anchoring to concrete are referred to as post installed anchors. There are several types of post installed anchors that include expansion anchors, chemical or adhesive anchors and undercut anchors. The criteria in Tables 9.3.5.8.9 (a), (b) and (c) are based on the use of a wedge expansion anchors and undercut anchors. Use of other anchors in concrete should be in accordance with the listing provisions of the anchor. Anchorage designs are usable under ASD methods. Values in tables 9.3.5.8.9 (a), (b), and (c) are based on an 8 to 1 safety factor in tension and a 4 to 1 in shear for allowable loads. Wedge anchors are torque-controlled expansion anchors that are set by applying a torque to the anchor's nut, which causes the anchor to rise while the wedge stays in place. This causes the wedge to be pulled onto a coned section of the anchor and presses the wedge against the wall of the hole. Undercut anchors may or may not be torque-controlled. Typically, the main hole is drilled, a special second drill bit is inserted into the hole and flare is drilled at the base of the main hole. Some anchors are self-drilling and do not require a second drill bit. The anchor is then inserted into the hole and when torque is applied the bottom of the anchor flares out into the flared hole and a mechanical lock is obtained. Consideration should be given with respect to the position near the edge of a slab and the spacing of anchors. Typically for full capacity in tables 9.3.5.8.9 (a), (b), and (c) the edge distance should be 1-1/2 times the embedment and 3 times the embedment for spacing between anchors.

3. Modify section 9.3.5.3.1 to read as follows, and add a new annex section A.9.3.5.3.1 to read as follows:

9.3.5.3 Lateral Sway Bracing.

9.3.5.3.1* Lateral sway bracing shall be provided on all feed and cross mains regardless of size and all branch lines and other piping with a diameter of 2½ in. (63.5 mm) and larger. Lateral brace assemblies in straight runs of pipe shall be capable of resisting the anticipated seismic loads and spaced to a maximum interval not exceeding 40 ft (12.2 m) on center. The load capacity of the brace assembly shall be determined by the capacity of its weakest component.

A.9.3.5.3.1 A brace assembly includes the brace member, the attachment components to pipe and building and their fasteners. There are primarily two considerations in determining the spacing of lateral earthquake braces in straight runs of pipe: (1) Deflection, and (2) Stress. Both deflection and stress tend to increase with the spacing of the braces. The larger the mid-span deflection, the greater the chance of impact with adjacent structural/non-structural components. The higher the stress in the pipe, the greater the chance of rupture in the pipe or coupling. For properly sized braces, the 40 ft maximum spacing between lateral braces in straight runs of pipe results in deflections and stresses consistent with the minimum required clearances in this standard and modern building codes. In the longitudinal direction, there is no deflection consideration, but the pipe must transfer the load to the longitudinal braces without inducing large axial stresses in the pipe and the couplings.

4. Delete Section 9.3.5.3.3.

5. Renumber Sections 9.3.5.3.4 through 9.3.5.3.8 as Sections 9.3.5.3.5 through 9.3.5.3.7.

Tentative Interim Amendment

NFPA 13

Standard for the Installation of Sprinkler Systems

2002 Edition

Reference: Table 12.1.10.1.1
TIA 02-2 (NFPA 13)
(SC 03-7-7/Log No. 732)

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2002 edition. The TIA was processed by the Automatic Sprinkler Systems Committee, and was issued by the Standards Council on July 17, 2003, with an effective date of August 6, 2003.

A Tentative Interim Amendment is tentative because it has not been processed through the entire standards-making procedures. It is interim because it is effective only between editions of the standard. A TIA automatically becomes a proposal of the proponent for the next edition of the standard; as such, it then is subject to all of the procedures of the standards-making process.

1. Modify last two columns Total Combined Inside and Outside Hose (gpm) and Duration (minutes), *of section Miscellaneous Tire Storage of Table, and Miscellaneous Group A Plastic Storage 12.1.10.1.1 as follows:*

					Miscellaneous Tire Storage					
Tires	On floor, on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 4		0, 50, or 100	~~750~~ 500	~~180~~ 120
	On floor, on tread or on side	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	~~750~~ 250	~~180~~ 90
	Single-, double-, or multiple-row racks on tread or on side	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	~~750~~ 250	~~180~~ 90
	Single-row rack, portable, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 4		0, 50, or 100	~~750~~ 500	~~180~~ 120
	Single-row rack, fixed, on tread or on side	>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 4		0, 50, or 100	~~750~~ 500	~~180~~ 120
		>5 to ≤12	>1.5 to ≤3.7	—	—	Curve 3	+ 1 level of in-rack	0, 50, or 100	~~750~~ 250	~~180~~ 90

Miscellaneous Group A Plastic Storage										
Cartoned	Solid and expanded	Palletized, bin box, shelf, and rack	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	~~500~~ 250	90
			>5 to ≤10	>1.5 to ≤3.05	15	4.6	Curve 4		0, 50, or 100	500	120
			>5 to ≤10	>1.5 to ≤3.05	20	6.1	Curve 5		0, 50, or 100	500	120
			>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 5		0, 50, or 100	500	120
			>10 to ≤12	>3.05 to ≤3.7	17	5.2	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
		Palletized, bin box, and shelf	>10 to ≤12	>3.05 to ≤3.7	27	8.2	Curve 5		0, 50, or 100	500	120
		Rack	>10 to ≤12	>3.05 to ≤3.7	—	—	Curve 3	+ 1 level of in-rack	0, 50, or 100	500	120
Exposed	Solid and expanded	Palletized, bin box, shelf, and rack	≤5	≤1.5	—	—	Curve 3		0, 50, or 100	~~500~~ 250	90
		Palletized, bin box, and shelf	>5 to ≤8	>1.5 to ≤2.4	—	—	Curve 5		0, 50, or 100	500	120
		Palletized, bin box, shelf, and rack	>5 to ≤10	>1.5 to ≤3.05	15	4.6	Curve 5		0, 50, or 100	500	120

Tentative Interim Amendment

NFPA 13

Standard for the Installation of Sprinkler Systems

2002 Edition

Reference: 12.1.13.4, 12.1.13.5, 12.1.13.6
TIA 02-3 (NFPA 13)
(SC 03-7-6/Log No. 731)

Pursuant to Section 5 of the NFPA Regulations Governing Committee Projects, the National Fire Protection Association has issued the following Tentative Interim Amendment to NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2002 edition. The TIA was processed by the Automatic Sprinkler Systems Committee, and was issued by the Standards Council on July 17, 2003, with an effective date of August 6, 2003.

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1. Revise Section 12.1.13.4 to read as follows:

12.1.13.4 Unless the requirements of 12.1.13.5 are met, the requirements of 12.1.13.2 and 12.1.13.3 shall not apply to modifications to existing storage application systems, using sprinklers with K-factors of 8.0 or less.

2. Add a new section 12.1.13.5 to read as follows:

12.1.13.5 Where applying the requirements of Figure 12.3.3.1.5(b) and Figure 12.3.3.1.5(c) utilizing the design criteria of 0.6 gpm/ft^2 per 2000 sq. ft. (186m^2) to existing storage applications, the requirements of 12.1.13.3 shall apply.

3. Renumber 12.1.13.5 as follows:

12.1.13.6 The use of quick-response spray sprinklers for storage applications shall be permitted when listed for such use.

Sequence of Events Leading to Publication of an NFPA Committee Document

Call goes out for proposals to amend existing document or for recommendations on new document.

▼

Committee meets to act on proposals, to develop its own proposals, and to prepare its report.

▼

Committee votes on proposals by letter ballot. If two-thirds approve, report goes forward. Lacking two-thirds approval, report returns to committee.

▼

Report — *Report on Proposals* (ROP) — is published for public review and comment.

▼

Committee meets to act on each public comment received.

▼

Committee votes on comments by letter ballot. If two-thirds approve, supplementary report goes forward. Lacking two-thirds approval, supplementary report returns to committee.

▼

Supplementary report — *Report on Comments* (ROC) — is published for public review.

▼

NFPA membership meets (Annual or Fall Meeting) and acts on committee report (ROP or ROC).

▼

Committee votes on any amendments to report approved at NFPA Annual or Fall Meeting.

▼

Appeals to Standards Council on Association action must be filed within 20 days of the NFPA Annual or Fall Meeting.

▼

Standards Council decides, based on all evidence, whether or not to issue standard or to take other action, including upholding any appeals.

Committee Membership Classifications

The following classifications apply to Technical Committee members and represent their principal interest in the activity of a committee.

M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.

U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.

I/M *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.

L *Labor:* A labor representative or employee concerned with safety in the workplace.

R/T *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.

E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.

I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.

C *Consumer:* A person who is, or represents, the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in the *User* classification.

SE *Special Expert:* A person not representing any of the previous classifications, but who has special expertise in the scope of the standard or portion thereof.

NOTE 1: "Standard" connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of members or unique interests need representation in order to foster the best possible committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

FORM FOR PROPOSALS ON NFPA TECHNICAL COMMITTEE DOCUMENTS

Mail to: Secretary, Standards Council
National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-9101
Fax No. 617-770-3500

Note: All proposals must be received by 5:00 p.m. EST/EDST on the published proposal-closing date.

If you need further information on the standards-making process, please contact the Standards Administration Department at 617-984-7249.
For technical assistance, please call NFPA at 617-770-3000

Please indicate in which format you wish to receive your ROP/ROC: ☐ paper ☐ electronic ☐ download

(Note: In choosing the download option you intend to view the ROP/ROC from our website; no copy will be sent to you.)

Date 9/18/93 **Name** John B. Smith **Tel. No.** 617-555-1212

Company ______________________

Street Address 9 Seattle St., Seattle, WA 02255

Please Indicate Organization Represented (if any) Fire Marshals Assn. of North America

1. a) NFPA Document Title National Fire Alarm Code **NFPA No. & Year** NFPA 72, 1993 ed.

b) Section/Paragraph 1-5.8.1 (Exception No.1)

FOR OFFICE USE ONLY

Log # ______________

Date Rec'd ______________

2. Proposal Recommends: (Check one) ☐ **new text** ☐ **revised text** ☒ **deleted text**

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted): (Note: Proposed text should be in legislative format: i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).

Delete exception.

4. Statement of Problem and Substantiation for Proposal: (Note: State the problem that will be resolved by your recommendation; give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

A properly installed and maintained system should be free of ground faults. The occurrence of one or more ground faults should be required to cause a "trouble" signal because it indicates a condition that could contribute to future malfunction of the system. Ground fault protection has been widely available on these systems for years and its cost is negligible. Requiring it on all systems will promote better installations, maintenance and reliability.

5. ☒ **This Proposal is original material.** (Note: Original material is considered to be the submitter's own idea based on or as a result of his/her own experience, thought, or research and, to the best of his/her knowledge, is not copied from another source.)

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John B. Smith

Signature (Required)

9/99B

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Fax No. 617-770-3500

Note: All proposals must be received by 5:00 p.m. EST/EDST on the published proposal-closing date.

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2. Proposal Recommends: (Check one) ☐ **new text** ☐ **revised text** ☐ **deleted text**

3. Proposal (include proposed new or revised wording, or identification of wording to be deleted): (Note: Proposed text should be in legislative format: i.e., use underscore to denote wording to be inserted (inserted wording) and strike-through to denote wording to be deleted (~~deleted wording~~).

4. Statement of Problem and Substantiation for Proposal: (Note: State the problem that will be resolved by your recommendation; give the specific reason for your proposal including copies of tests, research papers, fire experience, etc. If more than 200 words, it may be abstracted for publication.)

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